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EFFECTS OF CONTINUOUS AND INTERMITTENT TRAINING ON BODY COMPOSITION AND SELECTED PHYSIOLOGICAL PARAMETERS

BY

PAULO SERGIO CHAGAS GOMES ©

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
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Howard A. Wenger
External Examiner

Date March 14, 1989

DEDICATION

This work is dedicated to Tita and was inspired on

Daniel, Andre and Paulo Jr.

ABSTRACT

Based on their initial relative VO_2 max, assessed by means of a progressive cycle ergometer test, 33 male subjects were ranked in descending order. Subsequently they were subdivided in three groups and were submitted to 12 weeks of physical training on cycle ergometer. In addition, a group of six male subjects served as non-exercising controls (CG).

The first group (VTG) trained continuously at the ventilatory threshold two (VT2). The second (BVTG) group trained continuously at 15% below the VT2. The third group (ITG) exercised intermittently (1:1) at 100% of the VO_2 max. The total amount of work done per training session was equated in the three groups.

The experimental groups (pre, mid and post) and the CG (pre and post) were submitted to a protocol of anthropometric measurements, which included weight, seven skinfolds and the determination of body density.

During the course of the study a nutritional assessment was conducted in all experimental groups, by means of recall diaries.

The results of the study showed that power output at maximum exercise capacity increased significantly in all training groups but decreased in the CG. At VT2, power output significantly increased only in the VTG.

The absolute VO_2 max increased significantly in the VTG and ITG, but did not change in the BVTG and ITG groups. All *training groups significantly increased VO_2 max relative to body weight.*

Both the relative and absolute VO_2 at VT2 significantly increased in the VTG and ITG, but did not change in the BVTG.

Changes in VO_2 at max and at the VT2 were not related in all training groups (for individual groups or pooled data).

Body density increased significantly in the BVTG, with no significant changes in the other experimental groups. Changes in body density seemed to be due to training, since the subjects did not alter their nutritional intake during the twelve week training program. A significant reduction in the sum of skinfolds was observed in the BVTG, but this change was not related to the alteration in body density.

Changes in blood lactate and FFA concentrations during training did not seem to be related in any of the experimental groups.

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CHAPTER I

STATEMENT OF THE PROBLEM

I. INTRODUCTION

It has been suggested that under normal circumstances, adult humans tend to increase body weight up to the age of sixty (Parizkova, 1974). This increase in body weight is due mainly to an increase in the body fat compartment rather than an increase in lean body mass (Brozek and Keys, 1953). In western society, the average 35-year-old male tends to experience an increase of approximately 0.2 to 0.8 kg of fat each year (Parizkova, 1974). Fat-free weight remains either unchanged or decreases with age (Brozek, 1952; Norris et al., 1963; Forbes and Reina, 1970; Novak, 1972; Forbes, 1976). Exercise (Thompson et al., 1956; Thompson, 1959; Skinner et al., 1964; Oscai and Williams, 1968; Ribisl, 1969; Pollock et al., 1969; Moody et al., 1969; Carter and Phillips, 1969; Wilmore et al., 1970; Boileau et al., 1971; Wilmore et al., 1980; Depres et al., 1985) and exercise combined with food restriction (Passmore et al., 1958; Buskirk et al., 1963; Sprynarova and Parizkova, 1965) has been shown to be effective in reducing body weight and/or body fat.

Several exercise modes have been reported to cause changes in body composition of male and female non-athletes. Among these are walking/jogging/running (Oscai and Williams, 1968; Carter and Phillips, 1969; Pollock et al., 1971;

Wilmore, 1973; Getchell, 1975; Zuti and Golding, 1976; Pollock et al., 1976), bicycle/cycle ergometry (Johnson et al., 1972; Pollock et al., 1975; Smith and Stransky, 1976; Girandola, 1976; Wilmore et al., 1980) and circuit training/circuit weight training/weight training (Fahey and Brown, 1973; Girandola and Katch, 1973;Brown and Wilmore, 1974; Wilmore, 1974; Wilmore et al., 1978; Garfield et al., 1979).

Among competitive athletes, activities such as basketball, hockey, football, tennis and swimming have been shown to both decrease and increase body fat and/or weight (Thompson et al., 1956; Thompson, 1959; Katch et al., 1969; Wilmore et al., 1980).

Very few studies have made use of interval training methods (Bhambhani et al., 1987; Thomas et al., 1984), as a specific stimulus for body weight and/or fat reduction exercise training programs. These studies however, did not assess the nutritional intake of the subjects during the course of the training program.

Exercise-induced changes in body composition vary directly with the frequency, duration, and intensity of the activity (Wilmore, 1983). The American College of Sports Medicine Position Statement (ACSM, 1978) recommended that in order to reduce body fat, individuals should exercise at a minimum intensity of 50 % of the maximal oxygen consumption (VO_2 max) or 60 % of the maximum heart rate reserve (HRR max). It was also recommended that each training session should last session should last at least 20 minutes and be of a sufficient intensity and duration which would elicit an energy expenditure of approximately 300 kilocalories. This session should also be repeated a minimum of three times a week.

Exercise training prescription has traditionally been based on a relative percentage of VO_2 max and/or maximal heart rate (HR max) (Durnin, 1960; Jackson, 1968; Sharkey, 1970; Nupp, 1970; Davies, 1971; Fox, 1973 and 1975). The use of this approach may not always be appropriate since transition from aerobic to anaerobic metabolism is a very individual phenomenon, and depending on the intensity at which the subjects are training, different stress could be placed on the cardiorespiratory and metabolic systems. This individuality is demonstrated by the different responses to the same type of training in groups with similar initial levels of fitness reported by several authors (Ekblom et al., 1968; Kilbom, 1971; Pollock, 1973). Bhambhani (1982) in a review of 21 research articles observed that the percentage of the VO_2 max at the point of transition from aerobic to anaerobic metabolism ranged from 44.6 % (sedentary males) to 86.0 % (elite endurance runners).

The point of transition, or the shift from a primary dependence on aerobic metabolism to a transitional period of aerobic-anaerobic metabolism, has been commonly referred to as the anaerobic threshold (AT) (Wasserman and McIlroy, 1964; Wasserman et al., 1967; MacDougall, 1977; Reinhard et al., 1979). Reinhard et al. (1979) and Hagberg et al. (1982) observed that during a graded exercise test two metabolic thresholds exist, instead of one, as reported earlier. The first threshold occurs at an exercise intensity at which the level of blood lactate increases significantly above the resting value. At this intensity, no significant decrease in blood pH is observed (Reinhard et al., 1979; Hagberg et al., 1982). This is explained by the fact that most of the lactate produced is buffered by the sodium bicarbonate buffering system in the blood. As a result, an additional increase in expired CO_2 is observed.

The second threshold, which Reinhard et al. (1979) referred to as the "threshold of decompensated metabolic acidosis (TDMA)", occurs at an exercise intensity at which the lactic acid concentration increases disproportionately. This increase is due to the fact that the buffering capacity of the blood is exceeded. A significant decrease in the blood pH is also observed. In an attempt to compensate for this metabolic acidosis, the ventilation is stimulated resulting in a large increase in the volume of CO_2 (VCO_2) expired.

The two thresholds described above can be identified by continuously monitoring selected respiratory gas exchange parameters (Wasserman et al., 1973; Davis et al., 1976; Yoshida et al., 1981; Davis et al., 1982; Bhambhani and Singh, 1985). The first threshold (VT1) can be detected at the power output or the oxygen consumption at which the V_E/VO_2 ratio and the F_EO_2 reach a minimum (Reinhard et al., 1979; Bhambhani, *1982; Bhambhani and Singh, 1985). The second threshold (VT2) can be detected at the power output or the oxygen consumption at which the V_E/VCO_2 reaches a minimum and the F_ECO_2 reaches a maximum (Reinhard et al., 1979; Bhambhani, 1982; Bhambhani and Singh, 1985). As suggested by Hughes et al. (1982), the term "ventilatory threshold" should be preferred instead of the metabolic terms "aerobic and anaerobic threshold". The terms VT1 and VT2 as proposed by Bhambhani and Singh (1985), will be utilized in this study, denoting ventilatory threshold one and two respectively.*

II. THE PROBLEM

A. Training and Changes in Body Composition

As shown in an extensive review of the literature by Wilmore (1983), it is well established that exercise can be very effective in reducing body fat either singularly or in combination with a controlled nutrition program.

During light and moderate exercise, 50 % of the energy requirement is contributed by fat, with the other half by carbohydrates. As the duration of exercise increases, carbohydrates become depleted. Fat contribution (mainly FFA) may increase up to a total contribution of 80 % of the energy required.

Interval training (IT) methods have been excluded in favor of continuous training (CT) as an exercise stimulus to promote modifications in body composition (Wilmore, 1983).

However, there is evidence in the literature which has suggested that IT methods might be as effective as CT in utilizing fat as a substrate.

In an acute substrate utilization study, Essen et al. (1977) reported that FFA oxidation increases during the recovery period of intermittent exercise, and this increase is maintained until the subsequent exercise bout. It has also been demonstrated in animals that FFAs are utilized during intermittent work of high intensity (Snow et al.,1983). Essen (1977) offered the following explanation based on the work of Parmeggiani and Bowman (1963):

> Elevated citrate concentration was found at the end of the rest period supporting the suggestion that high citrate concentration might have an inhibition effect on the rate of glycolysis at the PFK level thus facilitating an enhanced lipid oxidation (p.40).

The acute responses to interval exercise are supported by the training data of Thomas et al. (1984). These investigators observed significant reductions in the percentage of body fat for both males and females that were submitted to IT (running) for 12 weeks.

IT programs have been shown to be as effective as CT in improving aerobic power (Roskamm, 1967; Fox et al., 1969 and 1973; Eddy et al., 1977; Gregory, 1979; Cunningham et al., 1979; Bhambhani et al., 1983; Thomas et al., 1984) and, it is likely that they might also be just as effective in inducing fat loss. In addition, IT is very appealing due to the fact that an individual training at high intensity can usually accomplish a higher total amount of work, as compared to CT, before experiencing localized fatigue. There is an evident need to further investigate the effects of IT on body composition and fat metabolism.

B. Training and Fat Distribution

Another aspect of interest is whether exercise induced body fat reduction is homogeneous throughout the body, and what is the relationship between total fat reduction and distribution.

There is some evidence in the literature which suggests that adipose tissue is not a homogenous entity. Animal models have shown that genital fat depots are specifically responsive to sex hormones (Krotkiewski and Bjorntorp, 1976; Steingrimsdottir et al., 1980). In humans, there is some indication in the literature that men treated with estrogen for cancer of the prostate showed significant enlargment of gluteal fat cells (Krotkiewsky and Bjorntorp, 1978). When men were treated with corticosteroids, effects on specific regional adipose tissue were observed (Krotkiewsky et al., 1976). Studies have also shown differences in the metabolic activity and hormone responsiveness of adipose cells from different fat depots of the body (Hamosh et al., 1963; Goldrick and McLoughlin, 1970). This was confirmed by Smith et al. (1979) who showed that the fat cells from the abdominal subcutaneous region were more hormonally responsive and metabolically active than the ones from the gluteal-femoral region. Obesity related disorders such as hypertension, diabetes, hypertriglyceridemia and insulin resistance have been shown to be associated with abdominal obesity (Kissebah et al., 1982; Krotkiewsky et al., 1983). Fat-cell size of the abdominal region has also been shown to be associated with the concentration of plasma insulin and triglycerides (Krotkiewsky et al., 1975).

Very few studies have looked at preferential subcutaneous fat reduction as a result of continuous aerobic training (Glick and Kaufman, 1976; Rognum et al., 1982; Bjorntorp, 1983; Despres et al., 1984 and 1985). The lack of similarity of exercise intensity, the utilization of fat biopsy in only one region, and the small number of subjects are among the reasons for the lack of conclusive results.

C. Substrate utilization during exercise

It is well documented in the literature that the oxidation of free fatty acids (FFAs) serves as the major source of energy for muscular exercise (Gordon, 1957; Fritz et al., 1958; Carlson and Pernow, 1959; Friedberg et al., 1960; Bosu et al., 1960; Friedberg and Estes, 1962). Depending upon the intensity and duration of the exercise, the primary substrate utilized will vary. During prolonged exercise of low intensity, the FFA will supply most of the energy required to perform the activity (Havel, 1971), and at this intensity very low levels of lactate are usually observed (Pruett, 1970). Havel and associates (1967) as well as Pruett (1970) observed that a high level of arterial lactate was associated with low levels of FFAs in men exercising at high work loads.

It has been reported that the accumulation of lactate during exercise has an antilipolytic effect. Issekutz and Miller (1962) were the first to report a decrease in plasma FFA as a result of lactic acid (LA) infusion in humans. Subsequent studies on animals confirmed that the decrease of plasma FFA was caused by the inhibition of the rate of release of FFA from the adipose tissue by high levels of LA (Miller et al., 1963; Issekutz et al., 1965b; Houghton et al., 1971; Issekutz et al., 1975). Issekutz et al. (1965a) reported a negative correlation between the exercise-induced rise in FFA turnover and that of plasma LA. In vitro studies on the isolated epididymal rat fat pad (Bjorntorp, 1965; Dieterle et al., 1969), and on the in situ perfused subcutaneous adipose tissue of the dog (Fredholm, 1971) have demonstrated a similar antilipolytic effect of LA. In man, Cobb and Johnson (1963) suggested an inverse relationship between plasma lactate and FFA. Boyd et al. (1974) reported that the release of FFA and glycerol was inhibited by the high levels of plasma lactate or pyruvate, or both.

Brooks and Fahey (1984) suggested that :

> During short-term, high intensity exercise, lactate accumulates as the result of greater lactic acid production than removal. At physiological pH, lactic acid, a strong organic acid, dissociates a proton (H^+)... High circulating H^+ levels will

> inhibit hormone sensitive lipase activity in adipose tissue, thereby limiting the release of FFA into the circulation (p.707).

The utilization of fat as the main energy source takes place when exercise is being performed at a low to moderate intensity. Increases in VO_2 max are observed as a result of training at intensities greater than 50 % of VO_2 max (Davies and Knibbs, 1971; Pollock, 1973; Hirsch, 1977; ACSM, 1978; Lipson et al., 1980; Allison et al., 1981). It is documented that the arterial LA levels start to rise once the oxygen intake reaches 50 % to 60 % of the maximal power (Hollman, 1963; Astrand and Rodahl, 1970; Davis et al., 1976). As a result, it appears that endurance training is performed at slightly elevated arterial lactate concentrations.

III. PURPOSES OF THE STUDY

The purposes of this study were:

1. To find the most effective training intensity - among two continuous and one intermittent - that simultaneously promoted a significant increase in body density and an increase in VO_2 max in an active non-athletic male sample.
2. To compare which of the three training intensities was the most effective in increasing oxygen consumption at the VT2.
3. To observe the relationship between changes in VO_2 at VT2 and changes VO_2 max as a result of training at different

exercise intensities.

4. To observe how does the size of the subcutaneous fat layer at selected sites of the body responded to the three training programs, and how this change wasrelated to alterations in body density.

5. To observe the interrelationships between the FFA and LA concentration in the blood during training, and changes in body density which resulted from the three training intensities.

The subjects in this study trained at a power output (kpm/min) requiring an oxygen uptake that was similar to the one observed at either the ventilatory threshold two (ventilatory threshold two group - VTG), at 15 % below ventilatory threshold two (below ventilatory threshold group - BVTG), or at 100 % of VO_2 *max (interval training group - ITG). The subjects in the ITG exercised at work:rest intervals of one minute each. The total amount of work per training session was equated for the three experimental groups.*

A group of active non-exercising male subjects were utilized for comparison purposes (control group - CG). The training program lasted for 12 weeks.

IV. HYPOTHESES

The following hypotheses were examined:

1. There is no significant difference between the three experimental groups, as a result of the three training intensities for the following dependent variables:

a) Sum of seven skinfolds (in mm), namely: triceps, biceps, subscapular, suprailiac, abdominal, front thigh, and medial calf;

b) Body density ($g.ml^{-1}$);

There is a significant difference between the control and the three training groups, as a result of the training program, for the dependent variables listed above.

2. There is no significant difference in the magnitude of the reduction of the subcutaneous fat at the various storage sites, as a result of training at the different training intensities. This was studied by changes in skinfold thickness at the different sites measured.

3. There is no significant difference between the experimental groups, as a result of training, for the following dependent variables:

a) VO_2 max (in $l.min^{-1}$ and in $ml.kg.min^{-1}$STPD);

b) VO_2 at VT2 (in $l.min^{-1}$ and in $ml.kg.min^{-1}$ STPD);

c) V_E/VO_2 ratio, and V_E/VCO_2 at the VO_2 max;

d) V_E/VO_2 ratio, and V_E/VCO_2 at the at VT2;

e) Power output (in kpm/min) at the maximum exercise capacity (MEC);

f) Power output (in kpm/min) at the VT2.

There is a significant difference between the control and the experimental groups for the variables outlined above.

4. There is no significant difference between the experimental groups, for the following dependent variables:

a) Changes in levels of circulating FFA (uEq.l^{-1}) in the venous blood measured at the tenth and twentieth minute;

b) Changes in levels of venous blood lactate (mMol.l^{-1}) measured at the tenth and twentieth minute.

V. LIMITATIONS OF THE STUDY

This study was subjected to the following limitations:

1. Variations in the measurements due to the calibration of the measuring equipment;
2. Subject attrition during the course of the study;
3. Subject life-style, including non-systematic physical activity;
4. Subject motivation during the maximum exercise capacity tests;
5. The assumption that all human adipose tissue has a density value within the range of 0.92 to 0.96 g.ml^{-1};
6. The assumption that the density of the human body falls within the range of 0.93 to 1.10 g.ml^{-1};
7. The assumption that the two compartment model - Fat Free Mass and Fat Free Weight (Behnke, 1954) - accurately describes the human body composition.
8. The assumption that the nutritional assessment indicated the actual energy intake of subjects, throughout the study.

VI. DELIMITATIONS OF THE STUDY

The delimitations of this study were:

1. The participation of a sample of 33 male volunteers from the Royal Glenora Club (Edmonton) and 6 college students, within the age range of 25 to 50 years;

2. The duration of the training sessions, three times a week for 12 weeks; and

3. The three training intensities.

VII. DEFINITION OF TERMS

The following are definitions for key terms appropriate to this study:

1. **Absolute Maximum Oxygen Consumption** (VO_2 max) - the maximum amount of oxygen that can be utilized (in $l.min^{-1}$, STPD) during exercise.

2. **Relative Maximum Oxygen Consumption** (VO_2 max) - the maximum amount of oxygen that can be utilized relative to body weight (in $ml.kg.min^{-1}$, STPD) during exercise.

3. **Maximum Carbon Dioxide Production** (VCO_2 max) - the maximum amount of CO_2 that can be produced (in $l.min^{-1}$, STPD) during exercise.

4. **Ventilatory Equivalent for Oxygen** (V_E/VO_2) - the ratio between the volume of air expired (V_E in $l.min^{-1}$, BTPS) and the volume of oxygen consumed (VO_2 in $l.min^{-1}$, STPD) at a particular exercise intensity.

5. **Ventilatory Equivalent for Carbon Dioxide** (V_E/VCO_2) -

the ratio between the volume of air expired (in 1.min^{-1}, BTPS) and the volume of carbon dioxide produced (in 1.min^{-1}, STPD) at a particular exercise intensity.

*6. **Ventilatory Threshold One** (VT1) - the power output (in kpm/min) or the oxygen consumption (in 1.min^{-1}, STPD or in % of VO_2 max) at which the V_E/VO_2 ratio and F_EO_2 reach a minimum.*

*7. **Ventilatory Threshold Two** (VT2) - the power output (in kpm/min) or the oxygen consumption (in 1.min^{-1}, STPD or in % of VO_2 max) at which the V_E/VCO_2 ratio reaches a minimum and the F_ECO_2 reaches a maximum.*

*8. **Anaerobic Threshold** (AT) - the exercise intensity or oxygen consumption (in 1.min^{-1}, STPD or % of VO_2 max) at which the level of blood lactate increases significantly above the levels observed at rest.*

*9. **Maximal Exercise Capacity** (MEC) - the power output at which the maximal oxygen consumption is attained or the subject is unable to continue exercising at 60 rpm, during a progressive exercise test on a cycle ergometer.*

*10. **Oxygen pulse** (O_2 pulse) - the volume of oxygen extracted per heart beat (ml.beat^{-1}) by the peripheral tissues.*

CHAPTER II

REVIEW OF THE LITERATURE

I. ANAEROBIC THRESHOLD: THE ORIGIN OF THE CONCEPT

As early as 56 years ago, W. Harding Owles (1930) confirmed previous works by Christiansen et al. (1914) and Douglas (1927) which noticed that above a particular exercise intensity muscles start producing lactic acid above the levels observed at rest. They also observed that this increase in lactate concentration in the blood was accompained by an increase in ventilation volume and in carbon dioxide production.

In the late fifties and early sixties, a group of German investigators headed by W. Hollman (1959, 1961, 1963) observed that when subjects were submitted to graded cycle ergometer exercise, with workload increments each three minutes, there was a point where the pulmonary ventilation would increase at a greater rate than oxygen consumption. This point was termed "point of optimal ventilatory efficiency", because pulmonary ventilation changes coincided with changes in arterial blood lactate. In the early sixties, Wasserman and McIlroy (1964) introduced the term "threshold of anaerobic metabolism" or simply "anaerobic threshold", that can be considered analogous to Hollmann's point of optimal ventilatory efficiency.

The term "anaerobic threshold" (AT) has been defined as the exercise intensity at which the level of lactic acid in the blood increases significantly above the resting levels (Wasserman and McIlroy, 1964; Wasserman et al., 1973). This first significant increase in lactate levels coincides with non-linear increases in ventilation, respiratory quotient and production of CO_2 (Wasserman and McIlroy, 1964; Wasserman et al., 1973; Wasserman, 1978).

Since it was introduced by Wasserman and McIlroy (1964), the term and the concept of anaerobic threshold have been extensively investigated by exercise physiologists. The threshold hypothesis has probably gained as many supporters (Davis et al., 1979; Matsumura et a., 1983; Caiozzo et al., 1982 and Powers, 1983), as non-supporters (Brooks, 1985; Hagberg et al., 1982; Hughson and Green, 1982; Green et al., 1983 and Yeh et al.,1983).

The concept of anaerobic threshold seems to have several important practical applications. Among them are:

1. The possibility of predicting the highest metabolic rate which can be maintained for long periods of time;
2. A more precise form of prescribing exercise. When attempting to equate work for different subjects, most of the investigators tend to use the same percentage of VO_2 max as the equating factor. Considering that 65% of the VO_2 max could be above AT for one subject and below AT for the second one, it is expected that the physiological response to the

activity performed at the same percentage of the VO_2 max will be different;

3. As compared to other physiological variables such as VO_2 max, percentage of slow-twitch muscle fibers, running economy, and percentage of body fat, the AT has been shown to best correlate with long distance or endurance events (Farrel et al., 1979; Powers et al., 1983; Kumagai et al., 1982);

4. AT can be used as a qualitative indication of an increase in lactate production (Wasserman et al., 1976), particularly in patients who may show a low (abnormal) cardiac frequency response to exercise, which could consider them as fit as a normal subject.

II. DETERMINATION OF ANAEROBIC THRESHOLD

The determination of AT has suffered a series of modifications since the initial work by Wasserman and McIlroy (1964). A review of the most common invasive and non-invasive methods follows.

A. INVASIVE DETERMINATION OF AT

Invasive techniques for detecting AT are very common in the literature. The AT is commonly identified at an exercise intensity where there is an increase in blood lactate concentration, with a simultaneous decrease in blood pH and bicarbonate concentration. Since a great number of studies that utilized blood analysis to determine AT use the term "Lactate Threshold (LT)", both terms will be used interchangly.

The lack of standardization of the protocols used and the subjective criteria to identify the threshold have weakened the comparison of the results from different studies. Blood samples have been collected from different sites such as arteries (Wasserman et al., 1973; Yoshida et al., 1981; Yeh et al., , 1983), capillaries (Kindermann et al., 1979 and Reinhard et al., 1979), the pulmonary artery (Weber et al., 1982), and from veins (Davis et al., 1976; Stanford et al., 1978; Pendergast et al., 1979; Ivy et al., 1980; McLellan et al., 1981; Caiozzo et al., 1982; Conconi et al., 1982; Hagberg et al., 1982; Yeh et al., 1983). The following are some of the criteria commonly used to determine AT:

1. Onset of an exponential rise in venous lactate (McLellan et al., 1981);
2. Slight increase in capillary lactate concentration (Kindermann et al., 1979);
3. Nonlinear increase in venous lactate (Pendergast et al., 1979);
4. Abrupt increase in venous lactate (Davis et al., 1976);
5. Increase in lactate above resting values (Wassermann et al., 1967);
6. Raise of lactate to an absolute value such as 2 or 4 mmol.l^{-1} (Mader et al., 1976a, 1976b; Kindermann

et al., 1979; Stegmann and Kindermann, 1982) or similar measures (Skinner and Mclellan, 1980 and Stegmann et al., 1981);

7. Rate of change of lactate [d(La)/dt] shows a sharp increase (Pessenhofer et al., 1981).

Yoshida et al. (1981) found that Lt determined by a venous blood lactate break point was systematically higher than the arterial blood lactate break point. An uptake of lactate from the forearm muscles before the blood reached the venous sampling site was explained by the authors as the possible reason for the differences encountered. Activity of the forearm was not reported to be controlled.

Another issue of concern is the fact that the determination of LT can be possibly affected by the exercise testing protocol. Ramp test protocol, as proposed by Whipp et al. (1981), has been used to show differences in LT when fast and slow increments are used (Hughson and Green, 1982). Using 25 watt increments, Wasserman et al. (1973) observed similar LT values, when workloads were increased either at one or four minute intervals. Yoshida (1985) duplicated the study by Wasserman et al. (1973) and found no significant differences between AT values as result of one and four minute increments. Buchanan and Weltman (1985) reported that cycle ergometer tests performed at 60 rpm in competitive cyclists resulted in different LT values when compared to tests performed at 80 and 120 rpm. This study supports the suggestion made by Boning et *al. (1984) that the determination of LT on cycle ergometer depends on the pedaling rate.*

In summary the determination of lactate threshold seems to lack of a standardized protocol. With this shortcoming in mind, one should be extremely careful when comparing the results from the different studies.

B. NON-INVASIVE DETERMINATION OF AT

The existing evidence of a relationship between endurance performance and AT (MacDougall, 1977; Farrell et al., 1979; Sjodin and Jacobs, 1981; Kumagai et al., 1982; Karlsson and Jacobs, 1983; Powers et al., 1983; Rhodes and McKenzie, 1984; Tanaka and Matsuura, 1984; Reybrouck et al., 1986), and the possibility of using non-invasive techniques to determine this threshold (Whipp and Wasserman, 1972; Wasserman et al., 1973; Davis et al., 1979; Moritani and de Vries, 1980; Davis et al., 1982), are probably the most attractive aspects of the concept of the anaerobic threshold, for exercise physiologists.

The use of respiratory gas exchange measurements is probably the most used method to determine AT during an exercise test. Two additional methods, the use of oxygen uptake kinetics (Whipp and Wasserman, 1972) and integrated electromyography (IEMG) (Moritani and de Vries, 1980) have been proposed, but none of these have been widely used by investigators.

Recently, Droghetti et al. (1985) proposed the use of the "deflection velocity (Vd)" as an alternative noninvasive method to determine AT. It was based on the relationship between running velocity (V) and heart rate (HR). The authors reported that in all athletes examined,

> ...the linearity of the V-HR relationship was maintained up to a submaximal speed (Vd), beyond which the increase in work intensity exceeded the increase in HR (p.299).

Correlation between Vd and AT determined by blood lactate concentration was .997 ($p<.001$) for a group of cross-country skiers, cyclists, roller-skaters, rowers, walkers and runners. As the IEMG method, this approach is yet to be fully tested by other investigators.

As mentioned previously, the use of gas exchange measurements is the most utilized method for the detection of AT. In their introductory paper on anaerobic threshold, Wasserman and McIlroy (1964) suggested that:

> ...the onset of anaerobic metabolism during exercise could be detected in three ways: (1) as an increase in the lactate concentration in blood, (2) as a decrease in arterial blood bicarbonate and pH and (3) as an increase in the respiratory gas exchange ratio (p.844).

Their suggestion was based on the evidence that the lactic acid produced during anaerobic metabolism was predominantly buffered in the blood by the sodium bicarbonate buffering system, with a reduction of bicarbonate levels. The carbonic acid formed was then dissociated into water and carbon dioxide increasing the partial pressure of carbon dioxide in the blood (De Lanne et al., 1959; Issekutz and Rodahl, 1961; Naimark et al., 1964). They also reasoned that in patients with heart failure when submitted to exercise, the excess CO_2 observed was released from bicarbonate when lactic acid was being buffered. The buffering of lactate by the bicarbonate buffer system and the excess of CO_2 described above, can be further explained by Equations 1 and 2.

$CH_2CHOHCOOH + NaHCO_3$ --> $CH_3CHOHCOONa + H_2CO_3$ Eq.1
Lactic Acid + Sodium Bicarbonate --> Sodium Lactate + Carbonic Acid

H_2CO_3 ----> $H_2O + CO_2$ Eq.2
Carbonic Acid -----> Water + Carbon Dioxide

The authors suggested that the AT could be easily detected by analyzing the respiratory exchange ratio (RER) breath-by-breath as described by Naimark et al. (1964) with RER calculated from end-tidal gas concentrations as follows:

$$R = FaCO_2/1.26\ FaN_2 - 1 + FaN_2$$

where:

$FaCO_2$ is the end-tidal CO_2 concentration

$$R = FaCO_2/1.26\ FaN_2 - 1 + FaN_2$$

where:

$FaCO_2$ is the end-tidal CO_2 concentration and

FaN_2 is the end-tidal N_2 concentration breath-by-breath.

Several studies followed the original work done by Wasserman and McIlroy on the concept of AT. They not only confirmed that AT could be detected by monitoring selected respiratory gas exchange measurements, but also refined the technique, established its reliability and validity (Davis et al., 1976; Weltman et al., 1978; Davis et al., 1979; Reinhard et al., 1979; Weltman and Katch, 1979; Rusko et al., 1980; Sady et al., 1980).

The use of respiratory gas exchange measurements is becoming more popular each day particularly because of the increasing availability of fast response microprocessor controlled gas analyzers and integrated units such as the MMC Horizon System (Sensormedics, Anaheim, USA). Although the gas measurements are collected very accurately (Jones, 1984) with practically no interference of the investigator, the varied and subjective criterion used to identify AT has made the comparison of different studies practically impossible.

Hughes et al. (1982) suggested that when AT is determined noninvasively by means of respiratory gas exchange measurements, the term "ventilatory threshold (VT)" should be preferred instead of "anaerobic threshold."

An extensive review of the studies that utilized gas exchange measurements' to identify AT is summarized in Table 1 (Appendix A).

In summary, as in the case of the determination of lactate threshold, there seems to be very little agreement, not only in the methods used for the determination of the VT, but also in the terminology that should be used to describe this physiological phenomenon. It is also evident from this review, that the VT can be used as an important tool in the prescription of exercise training intensity for athletic and non-athletic populations, and as important predictor of performance in middle and long distance events

III. OXYGEN FLOW AND LACTATE PRODUCTION

In 1924, Hill and co-workers observed that during exercise, lactate increased above resting values. They postulated that this increase in lactate was to provide a supplementary anaerobic source for energy generation when O_2 was reaching critically low values in the exercising muscle. This mechanism would permit exercise to proceed at high work intensities for a short time, despite an O_2 shortage.

The hypothesis that lactate formation is dependent on O_2 availability has been supported by several studies (Hogan and Welch, 1986; Hughes et al., 1968; Katz and Sahlin, 1987; Linnarson et al., 1974; Lundin and Strom, 1947; Rowell and al., 1984; Tirnay et al., 1971 and Woodson et al., 1978).

Brooks (1985b and 1986), in two review articles, questioned the threshold hypothesis on the basis that there was no conclusive evidence that during submaximal exercise (at 50 to 60 % of VO_2 max) the muscle tissue becomes anaerobic.

The use of $[^{14}C]$lactate tracer technique in different studies (Jorfeldt, 1970; Brooks et al., 1985a and 1985b) have led Brooks (1986) to conclude among other things that: a) during both rest and exercise, lactate production is not necessarily associated to muscle anaerobiosis; b) during sustained exercise, there appears to be both production and removal of lactate within an active muscle bed.

Studies such as the ones by Jobsis and Stainsby (1968), Donovan and Brooks (1983) and Cornett et al. (1984) have shown that lactate increases despite "good" O_2 supply. On the other hand, several investigators have observed that altering O_2 flow to the exercising muscles above a specific work rate affects blood and/or muscle lactate levels.

An increase in blood lactate has been observed as a result of: (a) decreased fraction of oxygen in the inspired air (F_IO_2) (Lundin and Strom, 1947; Hughes et al., 1968); (b) Linnarson et al., 1974); (c) acute isovolemic anemia (Neil et al., 1964; Woodson et al., 1978); (d) acutely binding hemoglobin sites for O_2 transport with carbon monoxide (Tirnay et al., 1971; Vogel and Gleser, 1972); (e) low cardiac output to a given work task (Harrison and Pilcher, 1930; Twentyman et al., 1981; Wasserman and Whipp, 1975); and (f) reduced circulating blood volume (Christensen and Christensen, 1978; Fortney et al., 1982).

A decrease in blood lactate has been observed as a result of: (a) increased F_IO_2 (Lundin and Strom, 1947; Perret, 1960; Hughes et al., 1968; Banister et al., 1970; Welch, 1977; Gautier et al., 1978); and (b) increased cardiac output response to exercise in cardiac patients (Siskind et al., 1980).

The so called "lactate shuttle" proposed by Brooks

(1985), suggests that a significant part of the lactate metabolism during exercise, is produced in fast-twitch glycolytic fibers and oxidized in fibers with a higher capacity for oxidation. In a recent review paper (Katz and Sahlin 1988), the authors concluded that "... data underlying the conclusion that lactate production during exercise is not O_2 dependent were found to be 1) questionable, or 2) interpretable in an alternative manner " (p.509).

IV. VENTILATORY THRESHOLD (VT)

The existence of two instead of one metabolic threshold, during a progressive exercise test, has been observed by several investigators (Kindermann et al., 1979; Reinhard et al., 1979; Skinner and McLellan, 1980; Hagberg et al., 1982; Bhambhani et al., 1983; Bhanbhani and Singh., 1985a, 1985b). Both thresholds can be identified very objectively by means of continuous monitoring respiratory gas exchange measurements (Reinhard et al., 1979; Bhambhani and Singh, 1985a).

The first "ventilatory threshold" (VT1), is analogous to Wassermann and McIlroy's AT (Wassermann and McIlroy, 1964; Wassermann et al., 1973). Kindermann et al., (1979) and Skinner and McLellan (1980) call this point "aerobic threshold (AeT)". As described in the previous section, this threshold has been identified at an exercise intensity at which V_E, VCO_2, and RER increase non-linearly (Wassermann and McIlroy, 1964; Wassermann et al., 1973; Wassermann, 1978), and a non significant decrease in blood pH is also observed because most of the blood lactate produced is buffered by the sodium bicarbonate buffering system (Reinhold et al., 1979; Hagberg et al., 1982).

The second "ventilatory threshold" (VT2) is analogous to what Kindermann et al. (1979) and Skinner and McLellan (1980) defined as the "anaerobic threshold", and Reinhard et al. (1979) termed as "threshold of decompensated metabolic acidosis (TDMA)". At VT2, there is a disproportionate increase in the production of lactic acid that exceeds the buffering capacity of the blood, and a significant decrease in pH (Reinhard et al., 1979).

Both VTs can be identified very objectively by using ventilatory equivalents for O_2 and CO_2 (V_E/VO_2 and V_E/VCO_2), as well as the fraction of expired O_2 and CO_2 (F_EO_2 and F_ECO_2). VT1 can be detected by the exercise intensity at which V_E/VO_2 ratio and F_EO_2 reach minimum, while VT2 can be identified by the exercise intensity at which V_E/VCO_2 ratio reaches a minimum and F_ECO_2 reaches a maximum (Figure 1).

A. RELIABILITY OF VENTILATORY THRESHOLD

Several studies have investigated the reliability of either VT1 or VT2 (Davis et al., 1979; Rusko et al., 1980; Nemoto and Miyashita, 1981; Whiters et al., 1981), but very few have looked at the reliability of both VTs (Aunola and Rusko, 1

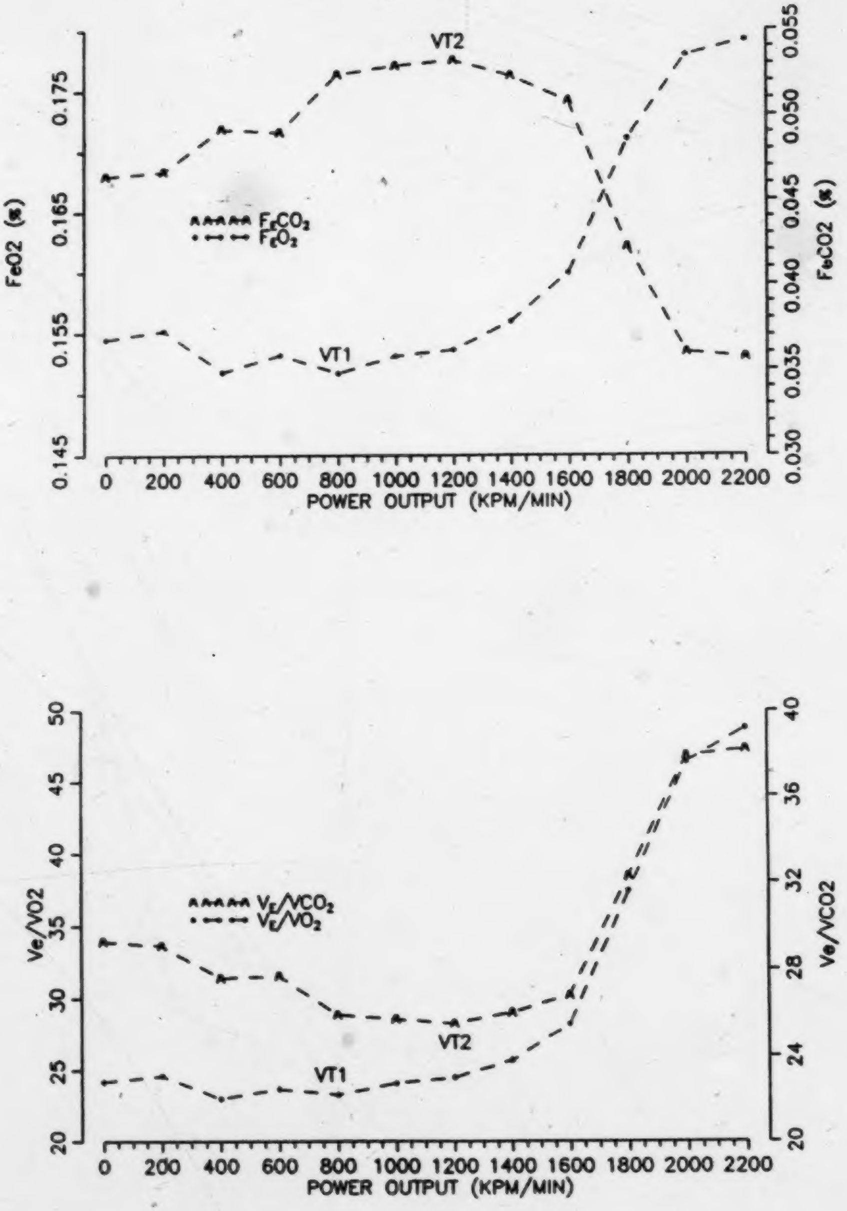


Fig. 1 - Determination of the ventilatory threshold one and two by means of gas exchange measurements, during a progressive exercise capacity test on cycle ergometer.

1984; Prud'homme et al., 1984).

Test-retest reliability coefficients have been reported by Davis et al. (1979) to be as high as 0.94 (pre-training) and 0.95 (posttraining) for VT1 (referred as AT) expressed in terms of VO_2 (l/min). These values are somewhat higher than a coefficient of 0.74 reported in a earlier study (Davis et al., 1976).

Rusko et al. (1980) found values of 0.95, 0.88 and 0.80 when the reliability of VT1 (referred as AT) was expressed in terms of l/min, ml/kg/min and percent of VO_2 max.

Conflicting results were presented by Yeh et al. (1982) who observed a high degree of variability in the identification of VT1 (also referred as AT).

Foster et al. (1986) concluded that both the ventilatory and lactate thresholds were not reproducible.

In a study by Prud'homme et al. (1984) the test-retest reproducibility as well as intertester reliability were investigated using two cycle ergometer and two treadmill tests. The authors concluded that both thresholds "...can be determined with a satisfactory level of reproducibility with the cycle ergometer protocol". They also concluded that the treadmill protocol produced reliable results for the VT2, but unsatisfactory for VT1. They suggested that the VT's should be assessed by "...two dependent evaluators performing the determinations followed by a conference to resolve differences and to yield a single estimate for each threshold".

Aunola and Rusko (1984) reported values of 0.94 and 0.96 for VT1 and VT2 respectively, when the threshold was expressed in terms of VO_2 (l/min).

The discrepancy in the assessment of reliability in the various studies is probably the result of the absence of a standard criteria to identify both VTs, as well as to variations in the samples used (homogeneity or heterogeneity of variance). Table 1 (Appendix A) summarizes the different criteria used to identify the thresholds.

V. EFFECTS OF TRAINING ON THE THRESHOLD

As evidenced in a previous segment of this chapter, several terms have been used to describe the threshold of anaerobic metabolism. Studies reviewed in this section were referred to by the term used in the original investigation. The reader should also consider that different methods were utilized to identify the threshold.

Davis et al. (1979) were probably the first to observe changes in VO_2 at AT as a result of training. After nine weeks of continuous training (5 days/week for 45 minutes/session) on cycle ergometer, a group of nine male subjects showed significant increases in VO_2 at AT, as well as VO_2 max. Training intensity was set to a target heart rate corresponding 50% (four weeks) and 70% (five weeks) between AT and VO_2 max. Yoshida et al. (1982) found similar results when their experimental group exercised on cycle ergometer for eight weeks

(15 min/session, 3 days/week) at an exercise intensity corresponding to 4 mMol of arterial lactate concentration. Denis et al. (1984) observed significant improvements in VO_2 at the "onset of blood lactate accumulation" (OBLA) in a group of 12 subjects training continuously on cycle ergometer at 80-85% of maximum heart rate (3.5 sessions/week, 60 min/session) for 20 weeks. The older subjects showed significantly higher improvements in VO_2 at OBLA as compared to the younger ones. Becker and Vaccaro (1983), studying a group of 11 nine year old children also observed significant increases in VO_2 at AT. In this study VO_2 max increased in both the exercise and control groups.

Ready and Quinney (1982) exercised a group of 12 male subjects (4 days/week, 30 min/session) at 80% of their VO_2 max for 9 weeks and found a significant increase of 74 % in VO_2 (l/min) at AT. Significant increase in VO_2 max was also reported by the authors.

Gaesser et al. (1984) also found no significant improvements in the ventilatory threshold of 6 male subjects training for 3 weeks (6 days/week, 30 min/session) on cycle ergometer, at 70% of the VO_2 max. Significant changes in VO_2 max were observed at the end of the training period. No control group was used for comparisons.

In another study lacking of a control group, Tanaka et al. (1986) added two exercise sessions to a normal training program of 20 middle-distance runners. The additional exercise sessions were performed at an intensity corresponding to the AT (or slightly above). The authors observed significant improvements in VO_2 max and VO_2 at AT after 4 months of training.

Using a test/retest procedure instead of a control group, Sjodin et al., (1982) observed a significant increase in VO_2 at OBLA in a group of 8 middle and long-distance runners, as a result of training at OBLA on a treadmill (once a week, for 20 minutes, for 14 weeks). This weekly exercise session was in addition to their regular training program. No improvements in VO_2 max were observed as a result of this additional continuous training.

Turcotte et al. (1985) exercised a group of males and females for 10 weeks (3 sessions/week) on an eight station hydraulic resistive exercise circuit. Initially, subjects performed 3 sets in each station, with each set consisting of 20 sec. of maximum effort followed by 40 sec. rest. After six weeks sets were increased to four. Training did not produce any changes in LT and 4 mMol point for both groups.

Improvements in VO_2 max, and VO_2 at AT seemed to be independent of the training intensity in a study carried out by Gibbons and associates (1983). A group of 29 females was submitted to a training program on a treadmill lasting 8 weeks (4 sessions/week, 20 min/session). Subjects exercised at an intensity eliciting a heart rate at AT, ((AT HR) + 40% * (MAX VO_2 HR - AT HR)), or ((AT HR) - 40% * (Max VO_2 HR - AT HR)).

No control group was used for comparisons.

Golden and Vaccaro (1984) found no improvements in either VO_2 max or VO_2 at AT as a result of training at intensities corresponding to the AT or 50% between AT and VO_2 max. Training sessions were carried on to groups of 6 male subjects, on cycle ergometer, 3 times a week (30 min/session) for 8 weeks.

Rivers et al. (1980) submitted a group of 24 female swimmers to 6 weeks of interval training, where the subjects trained either at approximately 84 (designated HITG group) of their best performance time or at the AT (4 mMol of lactate - designated ATG group). The authors reported significant gains in maximal aerobic, maximal alactic, and maximal lactic capacities as assessed by a tethered swimming test. Gains in the HITG group were significantly higher than the ATG group in all capacity variables.

Robinson and Suec (1980), Bhambhani et al. (1983), as well as Poole and Gaesser (1985) were the only investigators to compare the effects of interval and continuous training on AT. In the first study the authors exercised 16 active males for 12 weeks, running on a track. The continuous training group ran at approximately 85% of their VO_2 max, while the interval training group ran at an intensity equivalent to approximately 125% of their VO_2 max. The training groups were compared to a non-exercising control group, but total amount of work was not equated between groups. Both groups increased VO_2 max and VO_2 at AT, with the interval group showing higher increase in

AT expressed as a percentage of VO_2 max. The continuous training elicited higher gains in VO_2 max as compared to the interval group. No statistical significance was mentioned for both comparisons.

Bhambhani et al. (1983) in a more controlled study compared 3 training intensities in a group of low and high fit subjects. The total amount of work performed per session was equated for all groups that trained three times per week for 8 weeks on cycle ergometer. Subjects trained continuously at either 10% above AT (designated AT group), 50% between AT and maximal exercise capacity (designated ATG group) or intermittently (1:1) at 100% of VO_2 max (designated ITG group). Both fitness groups responded similarly to the three training intensities. All training groups increased power output and VO_2 at AT, threshold of decompensated metabolic acidosis (TDMA) and maximal exercise capacity. The only exception was the no significant increase in VO_2 at AT for the ITG group.

Poole and Gaesser (1985) observed somewhat similar findings in a group 17 male subjects training at either continuously at 50% of the VO_2 max for 55 min, continuously at 70% of VO_2 max for 35 min, or intermittently (2:2) at 105% of VO_2 max. The results of the study showed a significant increase in VO_2 max for all the groups, with no statistical difference between groups. LT increased similarly in all groups. VT also increased in all groups, but significantly more in the interval training group.

VI. ADAPTATIONS TO CONTINUOUS AND INTERMITTENT TRAINING

Basically two training models have been utilized by investigators in order to study the physiological adaptations to physical training. When exercise is performed uninterruptedly during a training session is referred to as "continuous" (CT). When intervals are interspersed with rest or recovery periods, it is called "interval" (IT).

Several authors have looked at the adaptations to CT and IT, but most of the studies have presented serious methodological problems. The most common problems usually were:

1. The total amount of work performed by the training groups not equated;
2. The training regimen based on percent of maximal heart rate, percent of VO_2 max, or best time to cover a particular distance;
3. The lack of a control group;
4. The pre- and post-test carried on a particular equipment while the training is done on a different one;
5. The training programs carried out for only a short period of time;
6. The small number of subjects;
7. The initial fitness level of the subject not taken into consideration;
8. The lack of reassessment and reassignment of workloads to subjects after three weeks of training. It has been shown that in order to further increase VO_2 max, the

training stimulus should be increased after three weeks of training (Hickson et al., 1981);

9. The inadequate statistical analysis.

One example of methodological problems is the study by Dolgener and Brooks (1978) who observed no significant differences in improvement between CT and IT in terms of VO_2 *max or time in the mile run, after six weeks of training. Fourteen subjects were pre- and post-tested on cycle ergometer but performed their training run on a track, with the exercise being prescribed on basis of 80% of maximal heart rate (designated CT group) or maximal effort (designated IT group). The CT group trained over a distance of one mile, with the running speed increasing weekly in order to maintain the desired intensity. The IT group trained over a distance of 220 yards, starting with eight repetitions on the first day and increasing to ten and twelve in the following days. This last increase in repetitions was kept constant throughout the rest of the study.*

In spite of the fact that most of the studies comparing IT against CT were not very well controlled, there is enough evidence in the literature to suggest that if total energy expenditure and/or total amount of work performed per training session are equated between the experimental groups, both training methods will produce similar results in improving aerobic capacity (Eddy et al., 1977; Cunningham et al., 1979; Gregory, 1979; Bhambhani et al., 1983; Thomas et al., 1984). Both methods seem to elicit significant improvements in VO_2

max (Eddy et al., 1977; Cunningham et al., 1979; Gregory, 1979; Bhambhani et al., 1983; Thomas et al., 1984; Gaesser et al., 1985), as well as in $\dot{V}O_2$ at the VT2 (Bhambhani et al., 1983).

As discussed, IT program can be as efficient as CT in improving $\dot{V}O_2$ max. The fact that an individual can accomplish a higher total amount of work as compared to CT, before experiencing local fatigue, makes IT a very appealing form of training.

VII. ADAPTATIONS IN BODY COMPOSITION AS A RESULT OF TRAINING

The effects of physical training on the body composition of humans have been one of the major concerns of exercise physiologists. The specialized literature is abundant in reports utilizing techniques that range from very expensive and sophisticated computerized axial tomography, nuclear magnetic resonance, use of scintillation counters to count the emission of Potassium - 40 (^{40}K), to very accessible and somewhat simple underwater weighing, volume displacement, and anthropometry (including the use of skinfolds).

The use of underwater weighing technique to predict body fat and lean body mass based on density, has become a normal routine in most of the exercise physiology laboratories and is probably considered as the standard method. This technique is based on Behnke's two-component model - fat mass and fat-free mass (Bhenke, 1942). The assumptions behind this model were discussed by Wilmore (1983):

> First, the densities of the fat and the lean components are known. Second, the densities of the components are relatively constant between individuals. Third, the density of the individual tissues of lean component, e.g., bone and muscle, are constant within and among individuals, and their proportional contribution to the density of the lean component remains constant. Finally, the individual being assessed differs from the standard "reference man", upon which a given equation is based, only in the amount of depot fat (p.22).

Some of these assumptions have been challenged by more recent studies, such as the one conducted by Martin and co-workers (1981). They observed variations in the density of the lean components as well as proportion of the components of the lean body mass after analyzing 12 cadavers.

The use of skinfolds to predict body fat, as an alternative to the underwater weighing procedure has become very much used by exercise physiologists. Regression equations are usually formulated in order to predict body density. Since the first equations were introduced by Brozek and Keys (1951), several investigators have proposed either generalized or population specific equations (Jackson and Pollock, 1978; Jackson et al., 1980).

A review of the literature on studies looking at the effect of training on the body composition of male adults is summarized in Table 2 (Appendix A). It is evident from that review that exercise training programs can be effective in reducing body fat. The magnitude of this reduction seems to be related to the type, intensity, and duration of the activity.

Probably, the major limitation of most of the training studies is the lack of information on the changes in energy intake during the training program.

VIII. EXERCISE AND FOOD INTAKE

In order to maintain body weight, the energy input should equal energy output in the "energy balance equation". The reduction in body weight can be accomplished by altering either one or both sides of the equation.

Most of the training studies reported in the literature fail to consider the possible changes in energy intake of the subjects involved in the program. Changes in body composition resulting from physical training, cannot be attributed solely to the training stimulus if one does not consider the possible changes in total amount of energy consumed by the subjects throughout the training program. In other words, most of the training studies have considered only one side of the equation.

In reviewing the literature Titchenal (1988) observed that the majority of the studies dealing with the relationship between energy expenditure and intake were not interested in changes in body composition as a result of training, but in the change in the energy intake itself.

The knowledge of the amount and/or composition of the nutrients being consumed by participants of training programs is of vital importance in drawing conclusions regarding the observed modifications in body composition.

McGowan et al. (1986) observed no significant changes in energy intake of men running 12.5 to 20 miles per week, when these changes were doubled or when running was stopped for 1-week periods. When sedentary controls were compared to active men (Montoye et al., 1976; Blair et al., 1981; Tremblay et al., 1985), the active subjects were found to consume more calories.

Studies on female (Parizkova and Poupa, 1963) and male (de Wijn et al., 1979) athletes have shown that during periods of training, the athletes increased their energy intake by 950 kcal/day as compared to periods of no training or reduced activity.

Kiens et al. (1980) observed changes in energy intake in sedentary middle-aged men when participating in a 12-week exercise program. Similar results have been reported for women (Blair et al., 1981; Smith et al., 1982 and Reggiani et al., 1984).

In contrast with the studies mentioned above, Dempsey (1964) reported no change in energy intake when young men were involved in a 13-week exercise program. Middle-aged men participating in a 9-month marathon training program showed similar results (Titchenal, 1986).

The lack of conclusive studies could be due to the methods used to assess nutritional intake. In recording food diaries it is likely that subjects will change their nutritional habits. Acheson et al. (1980) believes that subjects tend to under-report food intake due to the difficulty in recording their intake at the time of consumption.

Titchenal (1988), admits that food intake can be under-reported, but concluded that if this is consistent during repeated assessments, relative change could still be observed.

IX. FAT REDUCTION AND DISTRIBUTION

The size of the fat depot in the adipose tissue is determined by the fat cell number and their lipid content. It has been well established, in both animals and humans, that the adipocyte number is determined prior to maturation (Hirsch et al., 1966; Hirsch and Han, 1969; Hirsch and Knittle, 1970; Hollemberg et al., 1970; Hubbard and Mathew, 1971; Johnson et al., 1971). Further changes in the adipose tissue, after maturation, are usually associated with changes in the size of the adipocyte rather than the number of cells (Booth et al., 1973; Palmer and Tipton, 1973).

There is some evidence in the literature to believe that adipose tissue is not a homogenous entity. Animal studies have indicated that genital fat depots are more responsive to sex hormones (Kroktiewski and Bjorntorp, 1976; Steingrimsdottir et al., 1980). In humans, it has been reported that men treated with estrogen for cancer of the prostate showed significant enlargement of gluteal fat cells (Krotkiewsky and Bjorntorp, 1978).

Effects on specific regional adipose tissue were also observed when men were treated with corticosteroids (Krotkiewsky *et al., 1976). Studies by Hamosh et al. (1963) and Goldrick and McLoughlin (1970) have reported differences in the metabolic activity and hormone responsiveness of adipose cells from different fat depots of the body.*

Smith et al. (1979) observed that the fat cells from the abdominal subcutaneous region were more hormonally responsive and metabolically active than the ones from the gluteal-femoral region.

Studies by Kissebah et al. (1982) and Krotkiewsky et al. (1983) on obesity related disorders such as hypertension, diabetes, hypertriglyceridemia and insulin resistance have been associated with abdominal obesity. A typical example is the association of increased fat-cell size of the abdominal region and the elevated concentration of plasma insulin and triglycerides (Krotkiewsky et al., 1975).

Weight reduction studies, on obese patients, have shown that energy-reduced dietary regimen lead to a greater change in adipocyte size in the abdominal region than other sites (Bjorntorp et al., 1975; Kral et al., 1977). Smith et al. (1979) suggested that ". . . several mechanisms may be responsible for these regional differences in fat cell size such as differences in blood flow, innervation and/or responsiveness to hormonal stimuli" (p.331).

X. EFFECTS OF PHYSICAL TRAINING ON FAT DISTRIBUTION

Wilmore (1983), indicated in an extense review of the literature that:

> ...exercise training appears to result in moderate losses in total body weight, moderate-to-large losses in body fat, and small-to-moderate increases in lean body weight. The magnitude of these alterations varies directly with the frequency, intensity, and duration of the activity and the duration of the study (p.29).

Although there is enough research data demonstrating that exercise training can be very effective in reducing body fat, there are only a few studies that have looked at the relative contribution of deep and subcutaneous fat depots, or to the changes in fat distribution as a result of continuous or intermittent aerobic training. Most of the information dealing with fat distribution or reduction at different sites has emerged from studies carried out either on animals or with obese patients.

Earlier reports have shown that the morphology of subcutaneous fat is related to total body fatness and that increasing body fat mass seems to be associated with large fat cell sizes of different subcutaneous sites (Salans et al., 1973; Kirkland and Gurr, 1979; Bjorntorp, 1980; Clarkson et al., 1980; Chumlea et al., 1981).

Studies by Mole et al. (1971) and Costill et al. (1979) have indicated that adaptation to exercise training is present not only in the muscle, but also in the adipose tissue. The observation of small fat depots in endurance athletes (Leo et al., 1979; Wilcox et al., 1981; Depres et al., 1983) supports this indication and maybe confirm the fact that adipose tissue is the source for the free fatty acid mobilized during exercise.

Despres and associates (1985), observed no preferential reduction in body fat after an aerobic program carried over a period of 20 weeks in a group of 13 sedentary male subjects. Significant reductions were found in percent body fat, sum of seven skinfolds, and suprailiac fat cell size. The correlations between skinfolds and percent body fat were not altered as a result of the training program. Changes in skinfold thickness were correlated to their initial level, with the exception of biceps and calf skinfolds. Although preferential fat reduction was not observed, the authors reported that trunk subcutaneous fat stores (sum of subescapular, suprailiac and abdominal skinfolds) showed a reduction of 22% as compared to 12.5% of the extremity stores (sum of triceps, biceps, thigh and calf skinfolds). Two other similar studies by Despres and associates (1984a,b) confirmed these findings.

Leon et al. (1979) studying a group of obese young men submitted to 16 weeks, 5 days per week, of vigorous walking, observed significant reductions in body fat. In addition, they reported significant decreases in the sum of 7 skinfolds, as well as in 5 out of the 7 sites measured. No indication of preferential reduction was given.

Rognum and associates (1982) investigated a group of 12 male cadets of the Norwegian Military Academy who participated in a 107 hour combat course, which consisted of frequent, simulated combat activities. All subjects decreased body fat values and the result of the biopsy analysis showed the gluteal and abdominal subcutaneous regions with the most significant reductions.

A group of 129 newly recruited male subjects submitted to a training program in an army camp, was studied by Glick and Kaufman (1976). The subjects were analyzed in three groups based on the sum of three skinfold sites. They were grouped into small (21 mm or less), medium (25-35 mm), or large (50 mm or more). After 6 weeks of training, the authors observed an increase for the small group, no significant difference for the medium group, and significant reductions in the skinfold values for the large group.

In a study looking at the acute effects of a 23 mile run on long distance runners, Wilcox et al. (1981), contrary to their expectations, found an enlargement in the size of the fat cells of the abdominal and gluteal region. The elevated values of serum FFA and the enlargement of the fat cells demonstrated that the mobilization of fat from the adipose tissue did not occur. Another explanation could have been the mobilization of fat from depots of different regions.

Besides the lack of conclusive studies looking at preferential fat reduction as a result of training, there is a surprising lack of information on comparison of different training regimen and their impact on body composition.

CHAPTER III

METHODOLOGY

I. SUBJECTS

Thirty-three male subjects, members of the Royal Glenora Club, in Edmonton (Alberta), in response to an advertisement, volunteered to participate in this study. Six college students volunteered to serve as controls.

The objectives of the study, the testing and the training procedures, as well as the potential hazards of being involved in an exercise testing and training program, were explained to each candidate.

All volunteers were asked to answer the Physical Activity Readiness Questionnaire - PAR-Q (see Appendix E) to the best of their knowledge. Only the subjects who answered negatively to all the questions in the PAR-Q questionnaire, were considered for participation in the study.

None of the participants were under medical treatment or under any type of medication. They were physically active, but none was involved in any kind of systematic training program. All participants were also asked to sign an informed consent form which contained all the details of the study, which had been previously explained (see Appendix F);

II. EQUIPMENT AND GENERAL PROCEDURE

A. Gas Analysis

An automated Horizon Metabolic Measurement Cart, hereafter referred to as the MMC (SensorMedics, Anaheim, CA) was used for the analysis of the expired gases and computation of the metabolic variables under consideration. The instrument was interfaced with a Zenith microcomputer through a serial port, and was programmed to output data every 30 seconds. The MMC was calibrated, as per instructions of the manufacturer, prior to each testing session for temperature, volume, and partial pressures of oxygen and carbon dioxide. A complete description of this equipment and its validation has been published elsewhere (Norton, 1982; Jones, 1984).

The following parameters were recorded by the MMC:

1. Duration of measurement interval in seconds (time in sec);

2. Expired volume in liters per minute, ATPS (V_E in $l.min^{-1}$);

3. Fraction of expired carbon dioxide ($F_ECO_2\%$);

4. Fraction of expired oxygen ($F_EO_2\%$);

5. Temperature of expired gas as it passes through the volume transducer, in degrees Celsius (^oC).

The following physiological parameters were derived by the MMC:

1. Ventilation volume in liters per minute, BTPS (V_E in $l.min^{-1}$);

2. Absolute oxygen consumption in liters per minute, STPD (VO_2 in $l.min^{-1}$);

3. Oxygen consumption relative to body weight in milliliters per minute per kilogram of body weight, STPD ($ml.kg.min^{-1}$);

4. Carbon dioxide production in liters per minute, STPD (VCO_2 in $l.min^{-1}$);

5. Respiratory exchange ratio (RER).

Based on the physiological parameters computed by the MMC, a posteriori calculations provided the following ratios:

1. Ventilatory equivalent for oxygen (V_E/VO_2) - the ratio between the volume of air expired (V_E in $l.min^{-1}$ BTPS) and the volume of oxygen consumed (VO_2 in $l.min^{-1}$, STPD);

2. Ventilatory equivalent for carbon dioxide (V_E/VCO_2) - the ratio between the volume of air expired (V_E in $l.min^{-1}$, BTPS) and the volume of carbon dioxide produced (VCO_2 in $l.min^{-1}$, STPD).

B. Heart Rate Recording

Heart rates were monitored continuously during the exercise testing sessions (at rest, during exercise, and at recovery) using a portable electrocardiograph (Hewlett-Packard Model 1500 B, U.S.A.), interfaced with the MMC. Heart rates were displayed every 15 seconds, but recorded for 30 second periods.

The electrodes were placed at the CM5 lead position. During the training sessions, heart rate was continuously monitored (during exercise and recovery) by means of a Sportester model PE-2000 (Polar Electro, Finland).

C. Ergometry

Two electromagnetically braked cycle ergometers - Quinton Uniwork Ergometer Model 845 (Quinton Instruments, U.S.A.) were used for both testing and training sessions. All ergometers were calibrated periodically according to the procedures recommended by the manufacturer.

D. Exercise Testing Session

During the course of the study all subjects were tested on two occasions: in week zero (Pre) and thirteen (Post). Subjects in the three experimental groups, in addition to the Pre and Post tests, were submitted to the same procedures three more times during the study in order to have their power outputs re-assessed. These testing sessions were carried out in weeks three, six and nine, which corresponded to training sessions nine, eighteen and twenty-seven respectively (see Table 3).

In order to avoid variations in the testing situations, which could confound the results, all subjects were provided with the following written instructions prior to each testing session:

1. Refrain from ingesting food, and any type of

nutrients for at least two hours prior to the exercise testing;

2. Do not exercise or participate in any kind of vigorous physical activity 24 hours prior to testing session.

Upon arrival at the laboratory the subject was weighed as described in the anthropometry section. Immediately after, they were fitted with electrodes for monitoring the heart rate. A mouthpiece connected to the free end of the MMC was placed in the mouth of the subject, while a nose clip was used to prevent the subject from breathing through his nose. Expired gases during exercise were continuously monitored by the MMC for analysis. After adjusting the seat of the cycle ergometer to the most comfortable and efficient position of each subject, the subjects were seated and rested for ten minutes, before commencing the test. During this period, an explanation of the test protocol was once again given.

E. Exercise Testing Protocol

The exercise test was initiated with the subjects pedaling at 60 rpm with no resistance for a four minute period. Workloads were then increased every second minute by 200 kpm/min (33 watts), until the subjects reached their respective maximal exercise capacity (MEC) or could no longer maintain the pace of 60 rpm. The subjects were verbally motivated in order to carry on the exercise until the MEC was attained.

F. Detection of Ventilatory Threshold Two (VT2)

The VT2 was determined as the VO_2 (in $l.min^{-1}$) and the power output at which the V_E/VO_2 ratio reached a minimum and F_ECO_2 reached a maximum, during the incremental exercise test as described above (Figure 1).

1. Reliability of VT2

Seven active males subjects, who were not part of this training study, were tested twice, a week apart, in order to establish the test/retest reliability of the VT2. The exercise test protocol was identical to the one described above. The VT2 was determined in both occasions by the same investigator, based on the criteria described previously as suggested by Reinhard et al. (1979) and Bhambhani and Singh (1985).

G. Anthropometry

All subjects were submitted to the anthropometry protocol on two different occasions: at week zero (Pre), and at week thirteen (Post). The experimental groups, in addition to the Pre and Post, went through the same protocol at week six (Mid).

In order to minimize error, all measurements were taken by the same technician, who was certified in Kinanthropometric techniques by the International Working Group on Kinanthropometric Techniques. The subjects were asked to come for the testing sessions dressed in swimming suits to facilitate the technician in taking the measurements. Subjects were also asked to come in the morning, before the first meal and after voiding, and at least eight hours after their last meal.

The anthropometric measurements described below are part of the protocol recommended by the International Working Group on Kinanthropometric Techniques, endorsed by the Research Committee of the International Council of Sport and Physical Education - U.N.E.S.C.O.. The protocol is based on the deliberations of a Leon and the Korner Foundation study group and specifications by Ross et al. (1976). An in depth description of the following measurements has been published by Ross and Marfell-Jones (1982).

1. Standing Height

Using a stadiometer, the measurement was taken with the subject standing erect, barefoot, heels together, arms hanging naturally by the sides, and the heels, buttocks and upper back touching the wall. The measurement is defined as the maximum distance from the floor to the vertex of the head. The vertex is technically defined as the highest point on the skull when the head is oriented on the Frankfurt plane (imaginary horizontal line joining the anatomical landmarks orbitale to tragion). The measurement was recorded to nearest 0.1 cm.

2. Body Weight

The measurement was obtained by using a beam-type balance, previously calibrated and capable of readings to the nearest 0.1 kg. The subject was weighed in the swimming suit while standing still on the center of the balance platform, facing opposite to the weight scale.

3. Skinfolds

All skinfold measurements were taken on the right side of the subject, with the exception of the abdominal skinfold. In each testing session this protocol was repeated three times, with the average of the two closest values being used for the computations. A Harpenden skinfold caliper (British Indicator Ltd., Hertfordshire, England) with a constant pressure of 10.0 g/mm^2 of the caliper face at all thicknesses, was used to measure subcutaneous fat at predetermined sites, while the subject was standing unless indicated. The skinfold measurements were taken as described below:

a) Triceps - vertically at the midpoint between the anatomical landmarks acromiale and radiale, on the posterior face of the subject's arm;

b) Biceps- vertically at the midpoint between the anatomical landmarks acromiale and radiale, on the anterior face of the subject's arm;

c) Subscapular - at an angle of 45 degrees from the horizontal at a point beneath the inferior angle of the scapula;

d) Suprailiac - at a point seven centimeters above the anatomical landmark iliospinale on an imaginary *line that extends to the axilla. This skinfold extends downwards and inwards at an angle of 45 degrees from the horizontal;*

e) Abdominal - vertically at a point adjacent to the left of the anatomical landmark omphalion;

f) Front thigh - with the subject seated, the measurement is taken on the anterior face of the thigh along the vertical axis of the femur. The leg is flexed at a 90 degrees angle at the knee joint. The skinfold is measured at a point estimated as the half distance between the inguinal crease and anterior patella;

g) Medial calf - with the subject seated, the measurement is taken vertically on the medial calf at the estimated greatest circumference.

In all skinfold measurements the caliper was applied to the fold, one centimeter below the grasping fingers - left thumb and index finger - with the measurements recorded to the nearest one millimeter.

H. Hydrostatic Weighing

All subjects were administered the hydrostatic weighing protocol on two different occasions: at week zero (Pre) and at week thirteen (Post). In addition to the Pre and Post, the subjects in the experimental groups went through the same protocol on week six (Mid).

The same technician administered the procedure in all the sessions in order to minimize error. The subjects were informed to come for the testing sessions dressed in swimming suits. They were also asked to come in the morning, before the first meal and after voiding, and at least eight hours after their last meal.

The hydrostatic weighing procedure uses a tank filled with water in which a metal chair is suspended by means of cables which are connected to a strain gauge or load cell, which in turn, is connected to a Sargent recorder. The following is the protocol used:

Before the subject arrived:

1. The recorder was turned on and left in "standby" position for about 45 minutes;
2. With the recorder in "pen" position the recorder was calibrated to zero on the paper;
3. The weight belt (8.17 kg) was placed across the chair and the recorder calibrated to an arbitrary value of "75", keeping the recorder on 10mv span;
4. The recorder was then left in "standby" position.

When the subject arrived:

1. Body weight of the subject was recorded as described previously;
2. Water temperature was recorded for the purpose of correcting to specific density (see Appendix G for correction);
3. Subject was seated on the chair in the water with

the head above the water level;

4. The subject was asked to submerge his head and shoulders and remove air bubbles that might be trapped in the hair;

5. Residual volume was then predicted as described in the next section;

6. With the weight belt placed on the subject's thighs, the subject was asked to take a deep breath and submerge. The subject remained as stationary as possible and held his breath;

7. While the subject was submerged, the recorder was turned into "pen" position for recording. A signal was then made for the subject to rise;

8. A minimum of five recordings were done, with the lowest chart value being used for the calculations.

I. Prediction of Residual Volume

The residual volume (RV) was predicted as a percentage of the forced vital capacity (FVC) of the subject.

The VC was measured with the subject inside the tank, with the water up to the subject's chin. The measurement was taken using a 13.5 liter wet spirometer (Collins, U.S.A.). Each subject was measured several times, until three measurements differing less than 100 ml were obtained. Subjects were verbally encouraged to perform to the best of their ability. The average of the three values was use for computations.

The RV was predicted based the following criteria (Comroe, 1966):

1. Age = 16 to 34, RV (l) = VC X .250
2. Age = 35 to 39, RV (l) = VC X .305
3. Age = 50 to 69, RV (l) = VC X .445

J. Determination of Body Density

Body density was determined according to Archimede's principle, as described by McArdle et al. (1981).

> One subject either submerged or floating in water is buoyed up by a counterforce that equals the weight of water displaced. This buoyant force helps support the submerged object against the downward pull of the gravity. (p.372)

The following procedure (Sloan et al., 1962) was used to calculate body density:

Density = Wa / Volume - (R.V. + G.I.)

where:

Wa - Weight in the Air;

Volume = Weight in Air (Wa) - Weight in Water (Ww) / Density of Water (Dw);

G.I. - Gastro Intestinal Volume of Gas = 100 ml;

substituting in the formula:

Density (in $g.ml^{-1}$) = Wa / (Wa - Ww / Dw) - (R.V. + 100 ml).

A sample of the calculation of body density is given in Appendix H.

K. Prediction of Body Fat

Percent body fat was predicted based on calculations derived from body density using the equation derived by Brozek et al. (1963). The equation follows:

Percent Fat = ((4.570 / Body Density) - 4.142)) x 100

Body fat weight (in kg) was calculated as:

Body Fat = (Body Weight x FAT %) / 100

Lean Body Mass (in kg) was derived as:

Lean Body Mass = Body Weight - Body Fat

A sample of the above calculations is given in Appendix H.

L. Blood Sample

Twice during the study, at weeks two and twelve, during the training session, blood samples were taken from all subjects in the experimental groups. Subjects were asked to come early in the morning after fasting for twelve hours. Blood samples were drawn from an antecubital vein, at rest, at mid exercise, and immediately after the cessation of exercise.

1. Preparation for Lactic Acid Assay

Immediately after the blood sample was taken, 0.5 ml of fresh blood was added to 2 ml chilled 8% perchloric acid. After deproteinizing the blood, the sample was centrifuged for ten minutes at approximately 1500 x g. The supernatant was then stored in the freezer at -20 C. to be analyzed later on for lactate concentration using the enzymatic technique (Tietz, 1976). Sigma kits were used in the preparation of these assays, with all samples analyzed in triplicate with the average value being used for computations.

2. Preparation for Free Fatty Acid Assay

Immediately after the blood sample was taken, 1.0 ml of serum was transferred to a tube containing heparin and centrifuged at 3000 x g. The supernatant was then stored in the freezer at -20 C. to be analyzed later for free fatty acid concentration. All samples were analyzed in triplicate.

This method requires the preliminary manual chloroform extraction of free fatty acids from a phosphate buffer medium to eliminate the phospholipids interference. These chloroform extracts are then reacted with cupric nitrate reagent and the resulting chloroform soluble copper soaps formed complex with sodium diethyldithiocarbamate. The optical density of the resulting solution was measured at 440 nm. The detection limit of this assay is 2 $uEq.l^{-1}$ and the coefficient of variation at 50 $uEq.l^{-1}$ is 0.6 %. (Wang et al., 1987).

H. Nutritional Assessment

During the course of the study a nutritional assessment was conducted on all subjects by means of nutritional recall diaries (Appendix I). Total caloric intake was assessed with the data being analyzed by an experienced nutritionist utilizing the

Kelloggs/University of Alberta database (Appendix J).

In order to establish a baseline, all subjects were asked to record their dietary intake twice, for three consecutive days (Thursday, Friday and Saturday) in the two weeks preceding the study. In order to make comparisons, at week six (Mid) and week twelve (Post) the same procedure was repeated

III. RESEARCH DESIGN

A. Assignment of Subjects to Groups

Based on their initial relative maximal oxygen uptake values (assessed by means of a progressive cycle ergometer exercise test), the subjects were ranked in descending order. The individuals in the three experimental groups were then matched for initial VO_2 *max using the following randomization procedure.*

The 33 subjects were subdivided according to their rank order into 11 groups of three subjects each. From each of these 11 groups the subjects were randomly assigned to one of the three experimental groups. As a result, a stratified random sample of three groups of eleven subjects each were formed.

For comparison purposes, six physically active volunteers, not involved in any kind of systematic physical training, served as controls.

B. Experimental Groups

The experimental or training groups were submitted to a regular physical activity program with a duration of 12 weeks. Training sessions were carried out three times a week with a minimum of a 24 hours rest between training sessions.

C. Ventilatory Threshold Two Group (VTG)

Subjects in this training group trained continuously at a power output (kpm/min) requiring an oxygen consumption similar to that observed at the VT2 identified previously in a progressive maximal cycle exercise test.

D. Below Ventilatory Threshold Two Group (BVTG)

Subjects in this training group trained continuously at a power output (kpm/min) requiring an oxygen consumption which was 15% below that observed at the VT2 identified previously in a progressive maximal cycle exercise test.

E. Interval Training Group (ITG)

Subjects in this training group trained intermittently at a power output (kpm/min) requiring an oxygen consumption similar to the maximal oxygen consumption (100% of VO_2max) identified previously in a progressive maximal cycle exercise test. The work:rest intervals were of one minute each. The subjects continued to pedal with no resitance during the rest period.

F. Equating the Total Work per Session

The total amount of work performed per training session was equated in the three experimental groups. Each subject in the VTG group exercised for 20 minutes every training session. The total amount of work performed for each subject was calculated by multiplying the power output in kpm/min times 20 minutes. The duration of the training for the subject of the same rank order in the BVTG and ITG groups was calculated by dividing the total amount of work of the subject in the VTG by the power output at which the subjects of the same rank order in BVTG and ITG were supposed to train. Table 4 illustrates this procedure.

At training sessions nine, eighteen and twenty-seven, all subjects in the experimental groups were reassessed by means of a progressive maximal cycle exercise test (described previously). This was done, in order to adjust the training loads to their new physical conditioning. As a result, all training loads and training times were recalculated based on the new values obtained.

IV. EXPERIMENTAL DESIGN

The study comprised the following experimental designs:

1. A two-factor design in which Factor A had four levels, namely the control, and the three experimental groups, and Factor B had two levels namely the Pre and Post training values of selected physiological variables:

   a. VO_2 max ($l.min^{-1}$);

   b. VO_2 max ($ml.kg.min^{-1}$);

c. VO_2 at VT2 ($l.min.^{-1}$);

e. VO_2 at VT2 ($ml.kg.min^{-1}$);

f. Body density - BD ($g.ml^{-1}$);

g. Sum of seven skinfolds (mm);

h. triceps skinfold (mm);

i. biceps skinfold (mm);

j. subscapular skinfold (mm);

k. suprailiac skinfold (mm);

l. abdominal skinfold (mm);

m. anterior thigh skinfold (mm);

n. medial calf skinfold (mm).

2. A two-factor design in which Factor A had three levels, namely the three experimental groups, and Factor B had three levels namely the PRE, MID and POST training values of selected physiological variables:

a. Body density - BD ($g.ml^{-1}$);

b. Sum of seven skinfolds (mm);

c. triceps skinfold (mm);

d. biceps skinfold (mm);

e. subscapular skinfold (mm);

f. suprailiac skinfold (mm);

g. abdominal skinfold (mm);

h. anterior thigh skinfold (mm);

i. medial calf skinfold (mm);

j. Total energy intake (kcal).

3. A three-factor design in which Factor A had three levels,

namely the three experimental groups, Factor B had two levels, namely the two testing sessions, and Factor C had two levels, namely the tenth and twentieth minutes of exercise when the blood samples were collected. The following dependent variables were analyzed:

a. Lactic acid concentration - Lac (mmol.l.$^{-1}$);

b. Plasma FFA (uEq.l.$^{-1}$).

4. A two factor design in which Factor A had three levels, namely the three experimental groups, and Factor B had five levels, namely the five testing sessions. The following dependent variables were analyzed:

a. VO_2 max (l.min^{-1});

b. VO_2 max (ml.kg.min^{-1});

c. VO_2 at VT2 (l.min^{-1});

e. VO_2 at VT2 (ml.kg.min^{-1});

V. STATISTICAL ANALYSIS

The computer program "Statistical Package for the Social Sciences -SPSS X" (SPSS Inc, 1986), with the user procedure UANOVA written by the computer analyst (unpublished) at the University of Alberta, was utilized for the analysis of the data.

In addition to the variables specified in the design section, several other statistical analyses were carried in order to obtain additional information. The following computations were performed:

1. A two-way Anova with repeated measures on the second factor (4 X 2) (Winer, 1962; Keppel, 1973) was be used to compare the three treatment and one control groups at the two testing occasions. The following dependent variables were analyzed:

a. VO_2 ($l.min^{-1}$) at MEC;

b. VO_2 ($ml.kg.min^{-1}$) at MEC;

c. V_E ($l.min^{-1}$) at MEC;

d. V_E/VO_2 at MEC;

e. RER at MEC;

f. P.O. (kpm/min) at MEC;

g. VO_2 ($l.min^{-1}$) at VT;

h. VO_2 ($ml.kg.min^{-1}$) at VT;

i. V_E ($l.min^{-1}$) at VT;

j. V_E/VO_2 at VT;

k. RER at VT;

l. P.O. (kpm/min) at VT;

m. Body density - BD ($g.ml^{-1}$)

n. Body fat (%)

o. Body fat (kg)

p. Lean body mass (kg)

q. Sum of seven skinfolds (mm);

r. Individual skinfolds (mm)

2. A three-way Anova with repeated measures in the last two factors (3 X 2 X 2) (Winer, 1962; Keppel, 1973) was used to compare the three treatment groups, at the two testing occasions, at two data collecting points. The following

dependent variables were analyzed:

a. Lactic acid concentration - Lac ($mmol.l.^{-1}$);

b. Plasma FFA ($uEq.l.^{-1}$).

3. A two-way Anova with repeated measures in the second factor (3 X 5) (Winer, 1962; Keppel, 1973) was be used to compare the three treatment groups at the five testing occasions. The following dependent variables were analyzed:

a. VO_2 ($l.min^{-1}$) at MEC;

b. VO_2 ($ml.kg.min^{-1}$) at MEC;

c. V_E ($l.min^{-1}$) at MEC;

d. V_E/VO_2 at MEC;

e. RER at MEC;

f. P.O. (kpm/min) at MEC;

g. VO_2 ($l.min^{-1}$) at VT;

h. VO_2 ($ml.kg.min^{-1}$) at VT;

i. V_E ($l.min^{-1}$) at VT;

j. V_E/VO_2 at VT;

k. RER at VT;

l. P.O. (kpm/min) at VT;

4. A two-way Anova with repeated measures in the second factor (3 X 3) (Winer, 1962; Keppel, 1973) was be used to compare the three treatment groups at the three testing occasions. The following dependent variables were analyzed:

a. Body density - BD ($g.ml^{-1}$)

b. Body fat (%)

c. Body fat (kg)

d. Lean body mass (kg)

e. Sum of seven skinfolds (mm);

f. Individual skinfolds (mm)

5. A two-way Anova with repeated measures in the second factor (3 X 4) (Winer, 1962; Keppel, 1973) was be used to compare the three treatment groups at the four testing occasions. The following dependent variables were analyzed:

a. Training P.O. (kpm/min);

b. Training time (sec).

6. Intraclass correlation coefficients and paired "t" test for selected physiological variables measured at the ventilatory threshold (test/retest reliability):

a. VO_2 ($l.min^{-1}$);

b. P.O. (kpm/min);

c. Time (sec);

d. VO_2 (% of VO_2 max);

e. H.R. (bpm);

f. H.R. (% of H.R. max).

The .05 level of significance was considered for all ANOVA computations. When a significant F-ratio was observed, a post-hoc Duncan multiple range test (Winer, 1962) was applied to locate the specific differences. The .05 level of significance was also considered for post-hoc comparisons.

7. Pearson correlation coefficients for selected physiological variables, measured at the beginning and end of the study:

a. Change in lactate concentration at MID exercise with change in FFA concentration at MID exercise;

b. Change in lactate concentration at POST (POST - PRE) exercise with change in FFA concentration at POST (POST - PRE) exercise;

c. Change in lactate concentration at POST (POST - MID) with change in FFA concentration at POST (POST - MID).

The correlations were computed for both the pooled and group data, for each condition, at either the beginning or end of the study.

CHAPTER IV

RESULTS

I. CHARACTERISTICS OF THE SUBJECTS

Thirty-nine subjects completed the initial testing sessions. Thirty-three were distributed among the training groups (n=11 in each group), the remaining six subjects served as controls and were not involved in any systematic physical training. The physical characteristics of these subjects appear in Table 5 (Appendix C). Height, weight and VO_2 max (ml.kg.min^{-1}) were not significantly different among the four groups. The CG was significantly younger than the BVTG and ITG. The summary of the analysis of variance 'F' ratios appear in the Appendix K. The initial relative VO_2 max values for individual subjects in their respective strata are displayed in Figure 2. Mean values for each group, including the control, are presented in Figure 3.

A. Attrition Rate

Eight subjects, all from the the training groups, were forced to drop out of the study at different times. Five of these eight subjects experienced medical problems not associated with the training program. The other two did not complete the study for other reasons, also not related to the program. The subjects who dropped out were ranked 2, 4 and 8 in the VTG, 2 in

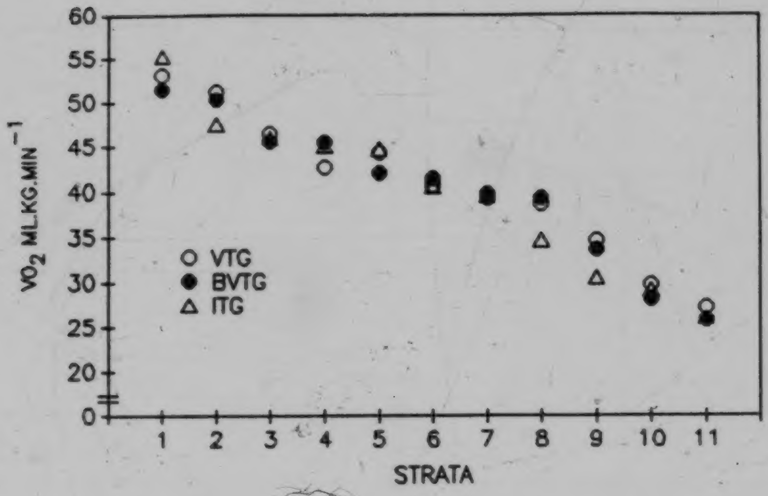


Fig. 2 - Initial relative VO_2 max values for individual subjects in the three training groups, according to their stratum, at the beginning of the study (N=33).

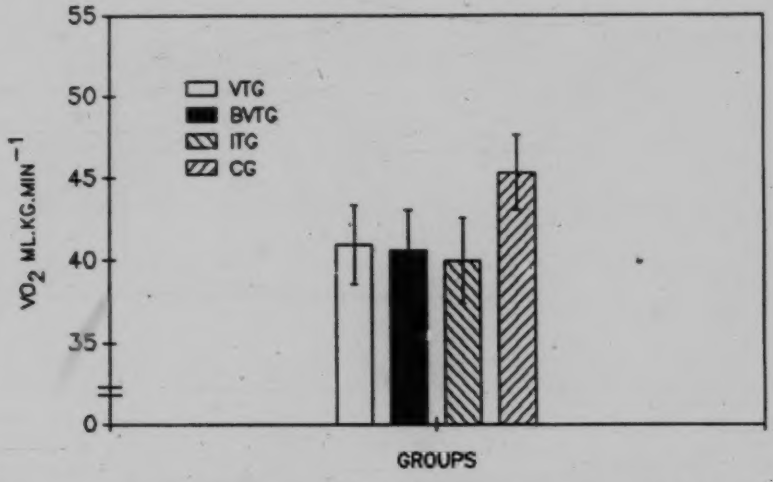


Fig. 3 - Initial VO_2 max relative to body weight, for the three training groups and the non-exercising control group at the beginning of the study (N=11 for each training group and N=6 for the control group).

the BVTG, and 5, 7, 8 and 10 in the ITG. The characteristics of the subjects (age, height, weight, and VO_2 max relative to body weight) that remained in the study, appear in Table 6 (Appendix C). There were no significant differences among the groups for the variables height and relative VO_2 max. The CG was significantly younger than the BVTG and ITG, and significantly lighter than VTG and BVTG. The analysis of variance 'F' ratios are summarized in the Appendix K.

II. RELIABILITY OF THE VENTILATORY THRESHOLD

The characteristics of the subjects that participated in the reliability study appear in Table 7 (Appendix C).

Intraclass correlation 'r' values, coefficient of determination, as well as 't' probability for the test/retest conditions for selected variables are summarized in Table 8 (Appendix C). The most reliable of the variables at VT2 was the power output ($r = .96$) and the least reliable was VO_2 expressed as a percentage of VO_2 max. Other correlation coefficient values were .87, .69, .88, and .78 for VO_2 ($l.min^{-1}$), VO_2 (% VO_2 max), heart rate (bpm) and heart rate expressed as a percentage of HR max respectively.

From these results, it seems that the VT2 can be reproduced with a high degree of reliability.

III. TRAINING VS CONTROL GROUPS

A. Physiological Adapatations at MEC

Tables 10 to 14 (these and all subsequent tables appear in Appendix D) show the Duncan post-hoc comparisons for the physiological variables studied at this intensity.

No significant differences were observed among the groups on the pretest for all the physiological variables studied at this intensity.

Both the VTG and ITG showed significant increases in both absolute and relative VO_2, as well as in O_2 pulse. There were no differences between these groups. The BVTG showed a significant increase in the relative VO_2.

The CG at postest, showed significant decreases in the V_E/VO_2 and V_E/VCO_2. A significant increase in V_E was observed in this group.

All three training groups significantly improved the power output attained at the MEC, but with no significant difference among them. A non-significant decrease was observed in the CG.

Significant changes were observed in the RER for the ITG (decrease) and CG (increase) groups.

Both the VTG and ITG were significantly different from the CG at postest for the variables V_E/VO_2 and V_E/VCO_2.

B. Physiological Adaptations at VT2

Tables 15 to 19 show the Duncan post-hoc comparisons for the physiological variables at this threshold.

None of the variables examined at this intensity were significantly different on the pretest. At postest however, V_E values for the BVTG and ITG groups were significantly lower than those of the VTG. No significant changes were observed for the CG group.

At postest, the VTG showed a significant increase in VO_2 (both $l.min^{-1}$ and $ml.kg.min^{-1}$) at the threshold, which was attained at a significantly higher power output. The ITG showed a similar result for VO_2 ($ml.kg.min^{-1}$), but with no significant change in power output.

The VTG also showed significant increases at postest, for V_E, VCO_2, HR, V_E/VO_2 and O_2 pulse. O_2 pulse was also significantly increased for the ITG as a result of training.

The CG did not show any significant change in the physiological variables measured at this condition, with the exception of a significant increase in RER.

C. Changes in Body Composition

Tables 20 to 24 show the Duncan post-hoc comparisons for the effects of the three treatment on body composition.

As compared to the Pre test, Post test values for BVTG showed significant decreases for body weight, body density, percent body fat, weight of fat and sum of seven skinfolds. The CG presented significant increases in body weight and sum of seven skinfolds.

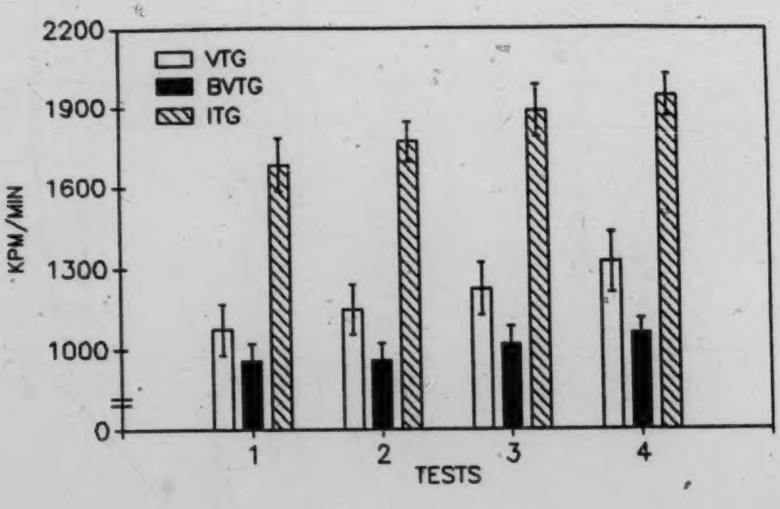
Both the VTG and BVTG were significantly different from the CG at Pre, in body weight , body density, percent fat, weight of fat and sum of seven skinfold (only the BVTG). With the exception of sum of skinfolds and body weight, these differences were also observed at Post. The ITG was significantly different from CG at Pre for body fat, but showed no difference at Post.

There were no significant differences between the training groups both at Pre or Post for these variables.

The analysis of the individual skinfolds showed significant decreases over time for triceps, subscapular, suprailiac, abdomen (BVTG). Significant increases were observed for biceps (VTG), suprailiac (ITG), subscapula and suprailiac (CG). As in the sum of skinfolds, the BVTG was significantly different from the CG for both triceps, subscapula and thigh skinfolds, at PRE. These differences did not exist at POST.

IV. THE TRAINING GROUPS

This section outlines the differences between the three training groups throughout the study. It is divided in two subsections: (a) chronic adaptations and (b) acute responses. Section "a" is subdivided into: (1) physiological adaptations at MEC; (2) physiological adaptations at VT2; (3) adapatations in body composition; and (4) changes in energy intake. Section "b" is divided in two subsections: (1) changes in blood lactate and FFA concentrations during training; and (2) relationship between



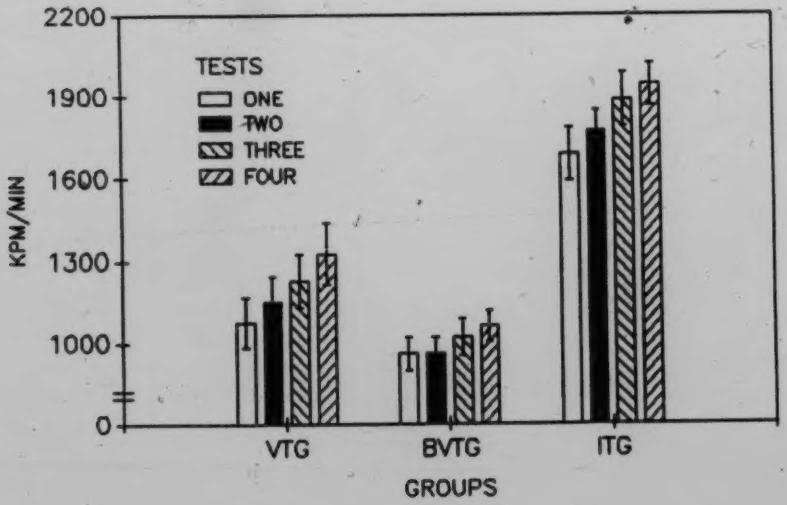


Fig. 4 - Training power output (mean and standard error of the mean) for the three experimental groups, determined at four different testing sessions throughout the study. Fig. 4a - group comparisons; Fig. 4b - test comparisons

blood lactate and FFA concentration.

During the study, in addition to the initial cycle ergometer test (T1), where training workloads were established for each individual, all subjects were reassessed after each eighth training session. As a result three new training workloads were prescribed throughout the study (T2, T3, T4). ANOVA results showed significant changes in training power output for all training groups over time. At T4 all groups showed significant differences from T1 and T2. The VTG also showed increased power output at T4 as compared to T3 and at T3 as compared to T1. At T3 the ITG showed significant improvements in power output in relation to T1 and T2 (Table 9).

In contrast, there were no significant changes in the duration of the training stimulus in any the groups.

A. Chronic Adaptations

1. Physiological Adaptations at MEC

Duncan post-hoc comparisons, given in Table 10, showed both the VTG and ITG groups to increase their absolute VO_2 max over time, T2, T3, T4 and T5 were significantly different from T1. These consecutive measurements though, were not different from each other. When VO_2 max was expressed relative to body weight, all three experimental groups snowed significant improvements in comparison to T1 (T4 and T5 different from T1). Changes observed in the BVTG were due to the significant reduction in body weight. Both VTG and ITG showed the same trend as observed in the analysis of the absolute VO_2 max. Once again the consecutive measurements did not show any statistical difference.

When comparing V_E at MEC (Table 11), both the VTG and ITG groups showed significant higher values as compared to the initial test (T1). All subsequent tests were significantly higher than T1, but there was no significant difference between T2, T3, T4 and T5.

VCO_2 values compared over time (Table 11), revealed T5 to be significant different from T1 for the VTG and ITG groups. The VTG also showed T5 to be different from T3, and T2 from T1. The ITG group in addition of T5, T4 and T3 were also different from T1. The BVTG showed no statistical difference over time, with the exception of the comparison of T4 and T3.

The effect of the three treatments on RER, given in Table 12, showed no consistent trend over time. At T3, both the VTG and BVTG differed from T1. The ITG group at T5 and T2 significantly reduced their RER values in comparison to T1.

At T5, all groups seemed to be able to exercise up to a higher heart rate, but only the VTG showed statistically significant higher values as compared to T1 (Table 12). Significant differences were also observed for the ITG group, at T5 and T4 (different from T1).

As a result of training, all experimental groups significantly improved their maximum power output (Table 13). At T5 and T4 all groups were statistically different from T1 and

T2. At T3, both the BVTG and ITG power output values increased in relation to T2 and T1. The VTG at T3 was also higher than T2, but not statistically different from T1.

The V_E/VO_2 results presented in Table 13, showed no measurable differences over time in any of the groups studied. The same cannot be said for the V_E/VCO_2 displayed in Table 14. Although there was no consistent trend in those changes, differences were observed for both the BVTG and ITG in relation to T1. Values measured at T5, T4 (only for the ITG), T3, and T2 were significantly different from T1. The BVTG also showed differences between T4 and T3.

The VTG (from T2 to T5) and ITG (at T5 and T4) showed significant changes in O_2 pulse as a result of training. These values were significantly different from T1, but no differences were observed between T1, T2, T3, and T4 (Table 14).

2. Physiological Adaptations at VT2

Duncan post-hoc comparisons for VO_2 at the VT for the three experimental groups are presented in Table 15. A similar trend was observed for both absolute and relative VO_2. The VTG showed a consistent and significant increase in VO_2 with time. Somewhat similar increases were observed for the ITG group, although these changes seemed to be of a lesser magnitude. No modifications were observed for the group training below the ventilatory threshold, for either absolute or relative VO_2.

The effects of the three different treatments on the physiological variables V_E and VCO_2 are given in Table 16. In both cases, the VTG demonstrated a significant increase at T5 and T4 in comparison to T1 and T3, and at T2 in comparison to T1. No significant changes were observed for these variables in the two other experimental groups (BVTG and ITG), with the exception of the ITG group at T2 being significant higher than T1 for V_E.

The RER comparisons given in Table 17 showed an inconsistent trend from T1 up to T3. At T4 all groups showed significant higher values than T3. The VTG values, in addition, were significantly higher than T1 and T2. All groups significantly decreased RER values at T5, but none were statistically significant.

Heart rate responses at this submaximal exercise intensity, showed both increases and decreases throughout the study, but only the group that trained at the ventilatory threshold point (VTG) showed significantly higher values at T4 (different from T1) and T5 (different from T1 and T3). These comparisons are presented in Table 17.

In comparison to the initial test (T1), only the VTG reached the ventilatory threshold at significant higher power outputs. As shown on Table 18, the VTG at both T5 and T4, had significantly higher values than T1 and T2. There were no differences between T4 and T5.

The V_E/VO_2 measured at the threshold did not change as a result of training, for either the BVTG or ITG groups. The

VTG though, at T5 and T4, showed a slight but statistically significant increase in comparison to T1 (Table 18).

The V_E/VCO_2 showed a similar trend for all training groups, which was an initial increase (T2), followed by a decrease (T4), and a post training increase at T5. Although the trend, presented in Table 19 was similar, the statistical analysis found both BVTG and ITG at T4 to be significantly lower than T2 and T3, and T2 (and T3 for the BVTG) to be significantly higher than T1. The VTG values at T2 and T3 were statistically higher than T1, T4 significantly lower than T2.

The O_2 pulse measured at the ventilatory threshold, slightly increased with training in both the VTG and ITG groups. Mean values at T2, T3, T4, and T5 were found to be significantly higher than T1 (and T3 for the VTG only). At T3, these values were significantly lower than T2. No changes were observed for the BVTG with the exception being at T2 which was higher than T1 (Table 19).

3. Adapatations in Body Composition

As mentioned previously, body composition was assessed three times (PRE, MID, POST) during the course of the study. ANOVA summary tables for all variables studied are given in the Appendix K.

Tables 20 to 24 display the mean comparisons for all anthropometric variables, for the three experimental groups, over the three test conditions. It is evident from these results that the BVTG, was the only group to present significant changes in the variables analyzed. Body weight at both MID and POST was significantly reduced from the initial PRE test. No differences were observed between MID and POST. In contrast, body density at POST, was significantly higher than the MID and POST measurements.

Percent body fat (Table 20), derived from the density values, body fat in kg (Table 21), and the sum of seven skinfolds (Table 21) showed the same trend as body density, with values at POST being significantly lower in the BVTG than at MID and PRE. No changes were observed for the VTG and ITG groups. Lean body mass was also unchanged throughout the study (Table 21).

The analysis of individual skinfolds (Tables 22 to 24) showed no change in the thigh and calf sites for any of the groups studied. The BVTG at POST, had a significant reduction in triceps, subscapula (also different from MID), suprailiac and abdomen, when these skinfolds were compared to PRE values. The VTG significantly increased the thickness of biceps skinfold at POST. The same happened to the ITG group for suprailiac skinfold.

4. Changes in Total Energy Intake

During the course of the study, all training groups presented a similar trend. Energy intake slightly decreased at the midpoint (MID) of the training program. At the end of the study (POST) a slight increase was observed for all groups.

These changes were higher in magnitude for the BVTG, nevertheless none were statistically significant (Table 25). ANOVA summary tables are given in Appendix K.

B. Acute Responses

1. Changes in Blood Lactate and FFA Concentrations

The acute changes in plasma lactate concentration during the training session at the beginning (BEG) and at the end (END) of the study for the three exercising groups, are given in Table 26. There were no significant differences between these acute responses at the BEG and END for the three training groups for the REST, MID and POST conditions.

There were no significant differences between the groups at REST for the BEG and END data. All groups significantly increased at MID for both the BEG and END. The ITG group at MID showed significantly higher values than both the VTG and BVTG at both the MID and END occasions. The VTG was also significantly higher than the BVTG at MID exercise, at the END occasion.

POST values were found to be significantly higher than REST, for all groups at the two occasions (BEG and END). At POST exercise, the ITG group values were also significantly higher than MID, at both BEG and END. These values were also significantly higher than the ones observed in both the BVTG and VTG (different from BVTG) groups.

Plasma FFA comparisons are given in Table 27. No differences were observed between these acute responses at the

BEG and END occasions in all groups for the REST, MID and POST conditions. No significant differences between groups at REST and at MID were observed at both the BEG and END occasions. At the POST condition, the BVTG showed significant increases in FFA concentration as compared to REST and MID. These changes were similar for both the BEG and END occasions. The BVTG was also significant different from the VTG at this condition, but only at the BEG occasion.

2. Lactate/FFA Relationships

The relationship between increases in lactate and FFA concentrations for the pooled, as well as for group data, are given in Tables 28 and 29. No significant correlation coefficients were observed in both BEG and END occasions, for either the pooled or group data.

CHAPTER V

DISCUSSION

I. METHODOLOGICAL CONSIDERATIONS

The discussion is the place where the investigator attempts to point out to the reader the differences between the results of his/her study and those found in the research literature, and explain the reasons for these differences. It should be emphasized that these comparisons should be viewed with some skepticism, due to the fact that although some studies carry somewhat similar objectives, the differences between methods, samples, statistical analyses, and different styles in reporting the results are usually a confounding factor.

The discussion is also the place where the researcher indicates to the reader if the present findings agree/disagree with theoretical expectations. The relationship between the purpose of the experiment, as stated in the introduction, and the decisions based on statistical or other methods, as reported in the results section, should also be handled in the discussion. The reader should keep in mind that "significance tests" have basically the sole purpose to establish whether a difference does or does not exist (Ahrens, 1971). These tests have the purpose to establish whether or not an observed difference could have arisen by chance alone (Gold, 1958). The importance of a difference should not be based only on the statistical significance, since it only tells you that a difference exists (Savage, 1957; Beshers, 1958; Morrison and Ramon, 1969). A difference may be of substantive importance without any statistical significance, which is common particularly in small samples.

Another issue that should be considered, is how should the data be analyzed. In a training study such as the present one, it is common that the investigator would tend to test for significance of the "difference scores" (i.e. post minus pre). This "difference scores" would represent a change in the dependent variable under scrutiny.

In this study raw data was preferred instead of the difference scores. As suggested by Kerlinger (1973) the use of analysis of variance for difference scores should be used if the experimental effects are expected to be substantial. Kerlinger also states that difference scores are usually less reliable than the raw data from which these scores were derived from.

II. RELIABILITY OF THE VENTILATORY THRESHOLD TWO (VT2)

It has been shown that during an incremental exercise test, two thresholds instead of one, exist (Reinhard et al., 1979; Hagberg et al., 1982). The first threshold is characterized by a significant increase in lactic acid in the blood, with no significant decrease in blood pH, because most of the lactate being produced is buffered by the sodium bicarbonate buffering system. The second threshold, is usually observed at a higher exercise intensity and percentage of the VO_2 max, and is characterized by a disproportionate increase in lactate production. At this point, a significant decrease in blood pH is observed, probably because of the inability of the blood to buffer the lactic acid being produced. This threshold, also called the "threshold of decompensated metabolic acidosis" (TDMA), can be objectively identified at the power output at which the V_E/VCO_2 reaches a minimum and the F_ECO_2 reaches a maximum (Reinhard et al., 1979; Bhambhani and Singh, 1985).

Prior to the beginning of the training study, the test/retest of the VT2 was investigated. The results of the present study showed the VT2 to be highly reproducible. The variables VO_2 (l/min), power output (kpm/min), time (sec), VO_2 (% of VO_2 max), heart rate (bpm) and heart rate (% heart rate max), all measured at the VT2 point, showed no significant difference when paired t-test was used to compare test and retest conditions. The VT was identified objectively in all subjects (Table 8).

Intraclass correlation coefficients for VO_2 (l/min) at VT (.87) were in agreement with the work by Prud'homme et al. (1984) which observed a value higher than .84 when the threshold was determined during a cycle ergometer (n=21) and treadmill (n=20) tests. The precise "r" values were not reported, and the threshold was determined by either three independent or three dependent investigators. An identification of a second disproportionate increase in V_E/VO_2 plotted against VO_2, was the criteria used by the authors to identify the threshold. The VO_2 at VT was higher for both the cycle ergometry (2.82 l/min or 86.2 % of VO_2 max) and treadmill (3.70 l/min or 85.6 % of VO_2 max) as compared to the present study (test = 2.61 l/min or 59.6 % of VO_2 max and retest= 2.55 l/min or 57.6 % of VO_2 max).

The present VO_2 data is also lower than the 2.75 l/min (77.0 % of VO_2 max) observed by Aunola and Rusko (1984) in a sample of thirty-three men aged 19 to 50 years of age, tested on cycle ergometer. These investigators determined the threshold in the same way as Prud'homme et al. (1984), and found the threshold to be highly reproducible (r = .96).

The present study also showed highly reproducible values for power output (.96) and heart rate (.88) at the VT. These results are also in agreement with the findings of Aunola and Rusko (1984).

Bhambhani and Singh (1985) examined the use of respiratory exchange variables to identify the two metabolic thresholds reported by Reinhard et al. (1979), and observed lower VO_2 values at VT when expressed in liters per minute (2.16), but higher than the present study, when expressed as a percentage of the VO_2 max (68.8).

As suggested by Reinhard et al. (1979), the threshold where decompensated metabolic acidosis occurs, can be easily identified by means of gas exchange measurements, without the necessity of using breath-by breath measurements. In addition, the study by Aunola and Rusko (1984) investigated the relationship between the threshold determined by the gas exchange and lactic acid criteria. Correlation coefficients were .92 and .93 for the test and retest respectively.

It appears, based on the results of the present investigation, that the use of V_E/VCO_2 and/or $FECO_2$ can be used to identify this threshold with a high degree of reproducibility.

III. EFFECTS OF PHYSICAL TRAINING ON PHYSIOLOGICAL PARAMETERS

The effects of training on the cardiorespiratory fitness of humans has been a constant research topic for exercise physiologists. Although the ultimate goal has often been the same, to find the optimal training program to improve aerobic power, the methods employed have varied extensively. The maximum amount of oxygen that can be utilized per unit of time during exercise, has been used as the best indicator of aerobic power.

Although the approaches have varied, most of the studies have dealt with the interaction between intensity, frequency and duration of training. The ACSM position statement is that when exercise is performed above a minimum threshold, the total amount of work accomplished is the most important factor in improving cardiorespiratory fitness (ACSM, 1978). In a more recent review on this topic, Wenger and Bell (1986) reinforced the belief that the alterations in cardiorespiratory fitness are directly associated with the length of the training programme, the exercise intensity and duration, the frequency of the sessions, and the initial fitness level of the subjects. They also concluded that the single most important factor was the intensity of the exercise.

A. Adaptations at the Maximum Exercise Capacity (MEC)

In this study, **maximal exercise capacity (MEC)** was operationally defined as the power output at which the maximal oxygen consumption was attained or the subject was unable to continue exercising at 60 rpm, during a progressive maximal exercise capacity test on a cycle ergometer.

This section discusses the adaptations that occurred at MEC as a result of three training intensities, two continuous and one intermittent.

1. Power Output, Absolute and Relative VO_2 max

Power output significantly increased in the three experimental groups (VTG, BVTG, ITG), but decreased in the control group (CG), with this decrease not being statistically significant (Table 13). A closer analysis showed that the changes in power output for both VTG, BVTG and ITG did not occur until the third assessment which was carried out after six weeks of training. Similar increases in power output with training have been shown by other investigators which used either continuous or intermittent training (Bhambhani et al., 1983), or continuous type of exercise (Golden and Vaccaro, 1984; Denis et al., 1984; Gaesser et al., 1984). In contrast, Eddy et al. (1977) reported no changes in power output at VO_2 max following a seven week training program in which subjects exercised continuously at 70 % of VO_2 max or intermittently at 100 % of VO_2 max.

Significant increases in absolute VO_2 max (l/min), were observed for both the VTG and ITG (Table 10), with no alterations being shown for either the BVTG or the CG (Figure 5). Increases in VO_2 max were first observed after three weeks of training. Although VO_2 values had a tendency to increase during the subsequent MEC tests, these changes were not statistically significant. These initial VO_2 max changes should be viewed with caution since the subjects may have not reached VO_2 max in the initial test. The BVTG showed consistently lower VO_2 values throughout the testing sessions, although in none of them these differences were statistically significant.

Modifications in VO_2 max relative to body weight were similar to the changes observed in power output. The three training groups significantly increased their relative VO_2 max, while the CG showed a non-significant decrease (Figure 6). When the experimental groups were observed through their five MEC tests (T1 to T5), both the VTG and ITG significantly altered their VO_2 max after three weeks of training. The group training at the lowest intensity (i.e. BVTG), did not experience

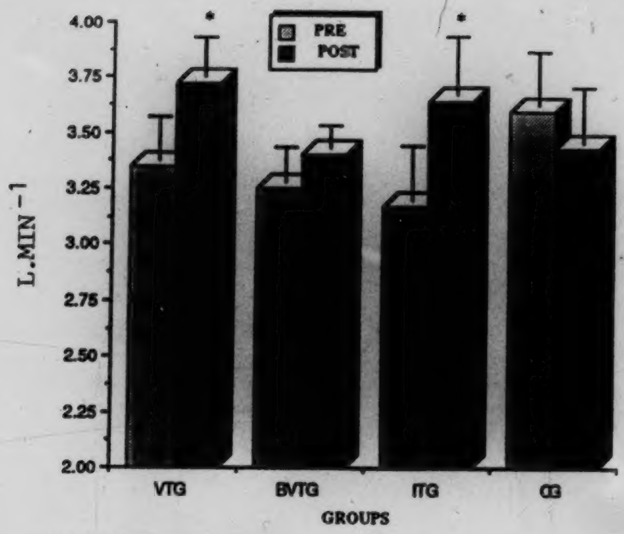


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Fig. 5 - Changes in absolute VO_2 *at MEC as a result of training at different exercise intensities.*

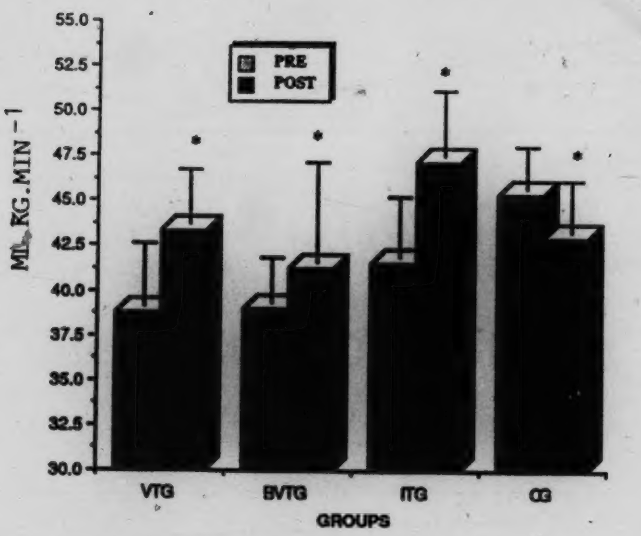

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Fig. 6 - Changes in relative VO_2 *at MEC as a result of training at different exercise intensities.*

any change in VO_2 max until nine weeks of training. Although some changes were observed between the testing occasions, these differences were not statistically significant.

When comparing the present results with previous studies in the literature (see summary in Table 30), it seems that the majority of the reports tend to show that exercising continuously above 60 % or intermittently at 100 % of the VO_2 max, significantly increases aerobic power. These changes also seem to be related to the initial fitness level of the subjects. It is important to note though, that some studies have compared different training intensities, without taking into consideration the total amount of work performed per session, in the different experimental groups.

The present results are in partial disagreement with the ones reported by Bhambhani and Singh (1985). In their study, subjects trained continuously at either 10 % above the ventilatory threshold one (TG) or at 50 % between ventilatory threshold one and VO_2 max (ATG), or intermittently at 100 % VO_2 max (ITG). Similar to the present investigation, the authors in that study equated the total amount of work per training session among the groups. All groups were reported to have shown a significant increase in absolute VO_2 max, probably due to their lower initial VO_2 values (Table 30). The present study had also higher final VO_2 max values as compared to those reported by Bhambhani and Singh.

2. V_E, V_E/VO_2, HR, and O_2 Pulse

The physiological values recorded at the point considered to be the subject's MEC were the ones used for comparisons.

Pre/post comparisons showed a significant increase in V_E (l/min) in the VTG and ITG, as well as in the CG (Table 11). Increases in V_E max have been reported by other authors, as a result of continuous or interval training (Pollock et al.,1976; 1972; 1969; Lesmes et al.,1978; Ready and Quinney,1982), which substantiate the present findings.

Since V_E/VO_2 was unchanged in any of the training groups, it implies that the changes in V_E and VO_2 were proportional to each other (Table 13). These results are in agreement with those reported by Bhambhani (1982), but in contrast with other reports (Milic-Emili et al., 1962; Jirka and Adams, 1965; Adams et al., 1974; Girandola and Katch, 1976; Davis et al., 1979; Bradley et al., 1980; Ready and Quinney, 1982), which observed significant decreases in the oxygen cost of ventilation at the MEC, as a result of endurance training.

When posttraining HR max values were compared to values measured at the beginning of the study, no significant changes were observed for the BVTG, ITG and CG. Significantly higher values were observed only for the VTG as a result of training. When the experimental groups were analyzed over time (Table 12), significant increases were observed for both the VTG (T5 from T1) and ITG (T4 and T3 from T1). Similar results were observed by Getchell and Moore (1975), which exercised twelve middle-aged sedentary males for ten weeks, three to four times a week. Subjects in this study ran or jogged for twenty minutes at an intensity of 75 to 85 % of the predicted HR max.

It is well accepted that HR max is not affected by training despite the fact that the maximal power output is significantly increased (Astrand and Rodahl, 1986). Experimental studies have shown no changes in HR max (Girandola and Katch, 1973; Davis et al., 1979; Wilmore et al., 1980; Yoshida et al., 1982; Poole and Gaesser, 1985), but a close inspection of the related literature indicates that several authors have reported significant decreases in HR max as a result of continuous or interval training (Pollock et al., 1969; Fox et al., 1972; Pollock et al., 1972; Knuttgen et al., 1973; Fox et al., 1975; Pollock et al., 1975; 1976; Cunningham et al., 1979; Gettman et al., 1979). It is common not to attain maximum heart rate (predicted for age) during an incremental exercise test in cycle ergometry due to localized fatigue. Since subjects usually experience a local adaptation due to the training stimulus higher heart rates would eventually be reached. Since the subjects trained on cycle ergometer, this would seem to be a possible logical explanation for the increases observed in HR max in the present study. It should be noted though, that some of the studies that reported changes in HR max as a result of training, were carried out on a treadmill (Pollock et al., 1969; 1972; 1976; Gettman et al., 1979).

At the end of the training program O_2 pulse values were significantly higher in the VTG and ITG groups. No differences were observed for either the CG or the BVTG (Table 14). These findings are in agreement with previous studies in which subjects were exercised continuously at 80 and 90 % of HR max (Pollock et al., 1972) or intermittently at a non-specified exercise intensity (Pollock et al., 1969). In another study, subjects jogged between 5 and 7 miles, three times a week for twenty weeks. At the end of the training program, significant increases in O_2 pulse were reported (Pollock et al., 1976).

B. Adaptations at the Ventilatory Threshold (VT2)

The VT2 was operationally defined as the VO_2 (in l/min) at the power output at which the V_E/VCO_2 ratio reached a minimum and F_ECO_2 reached a maximum, during an incremental cycle exercise test.

As there are very few training studies that utilized VT2, comparisons were made with reports that quite often used different methods and terminologies, such as anaerobic threshold or lactate threshold. Considering that there can be significant differences between the variables measured at these different points, the reader should refer to Table 31 for the terms and definitions used in this discussion. As has been suggested, "thresholds should be named based on the parameters used to measure them" (Walsh and Banister, 1988 citing Bhambhani and Singh, 1985 and Hughes et al., 1982)

1. Power Output, Absolute and Relative VO_2

At the end of the training program, the VTG was the only group to show a significant increase in power output (20.9 %), although the two other experimental groups attained VT2 at a slightly higher power output. These increases were in the magnitude of 4.3 % and 2.6 % for the BVTG and ITG respectively. No significant changes were observed in the CG (Table 18). The lack of significance (BVTG and ITG) can be explained by the fact that during the incremental exercise test power output was increased by 200 kpm/min every two minutes. This could have misrepresented the determination of the power output at the VT2.

Initial VO_2 (l/min) values were similar to the ones reported by other authors for a nonathletic sample (Denis et al., 1988; Smith and O'Donnell, 1984), but lower than the study by Bhambhani et al. (1983). The present VO_2 data were higher than those observed by previous investigators using different criteria (Hill et al., 1987; Poole and Gaesser, 1985; Ready and Quinney, 1982; Yoshida et al., 1982; Davis et al., 1979). Table 32 summarizes the training studies which looked into the physiological changes at the threshold (using different criteria).

The absolute and relative oxygen consumption at the VT2 (Figures 7 and 8) increased significantly as a result of training continuously at VT2 (27 %) or intermittently at 100 % of the VO_2 max (12 %), but did not alter in the BVTG. The nonexercising controls did increase their VO_2 values by

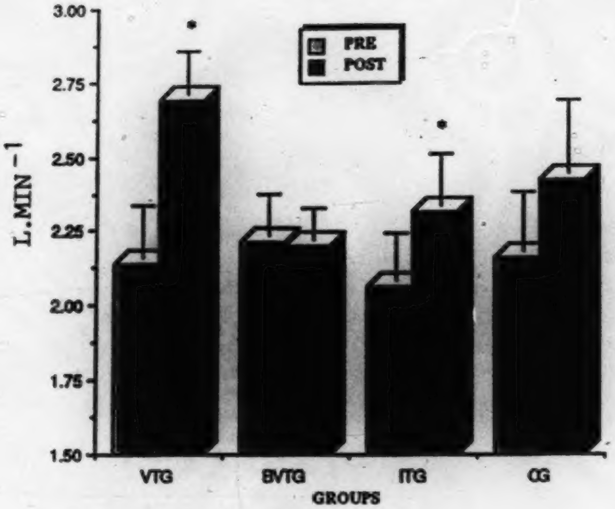

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Fig. 7 - Changes in absolute VO_2 at the VT2 as a result of training at different exercise intensities.

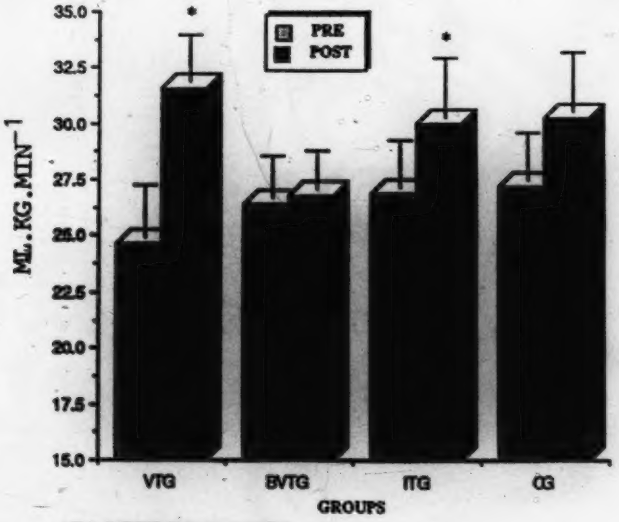

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Fig. 8 - Changes in relative VO_2 at VT2 as a result of training at different exercise intensities

12.0 %, but this change was not statistically significant (Table 15). With the exception of one study (Golden and Vaccaro, 1984), all the studies reviewed showed significant changes in VO_2 at the threshold. In these studies different criteria were used to identify the threshold. Percent increases varied from 70.4 (Ready and Quinney, 1982) to 18.5 (Poole and Gaesser, 1985). Bhambhani et al. (1983), using the same criteria as the present study, observed significant changes of 12.8 % (continuous cycling at the VT1), 51.1 % (continuous cycling at 50 % between VT1 and MEC), and 24.2 % (intermittent cycling at 100 % VO_2 max). In another study using the same criteria (Denis et al., 1988), observed changes (26.3 %) were somewhat similar to the present investigation. The authors exercised college students continuously on cycle ergometer at 70-80 % of the VO_2 max, four days a week, one hour a day, during a 20-week training program.

When VO_2 at the VT2 was expressed in % of VO_2 max, it ranged between 60.2 (CG) to 68.3 % (BVTG) at the beginning of the study, and 63.4 (ITG) to 72.4 % (VTG) at the end of the study. When compared to other investigations, depending on the criteria used to identify the threshold, these values could be anywhere from much lower than the reported values (Poole and Gaesser, 1985), similar (Becker and Vaccaro, 1983), to much higher (Ready and Quinney, 1982) than the present values.

Changes in VO_2 max did not seem to be related to changes in VO_2 at VT2. Correlation coefficients calculated for

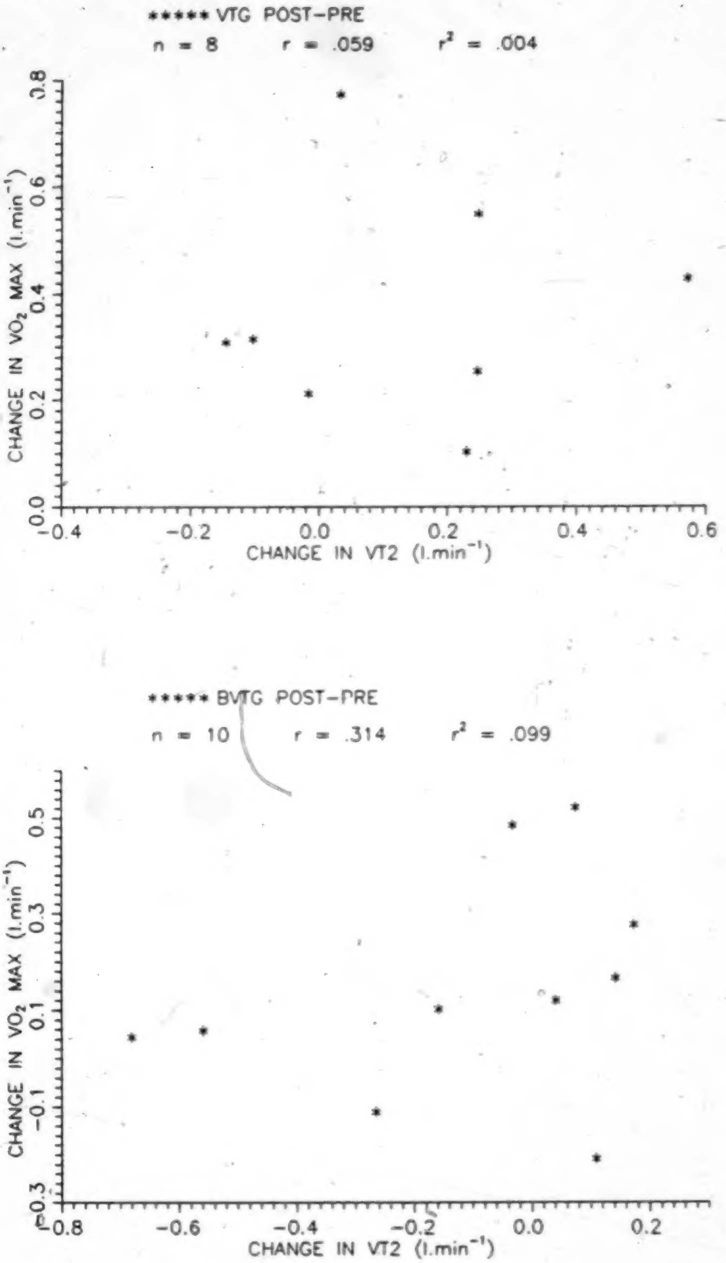


Fig. 9 - Relationship between changes in VO_2 at MEC and VO_2 at the VT2 as a result of training at different exercise intensities (Fig. 9a - VTG; Fig. 9b - BVTG).

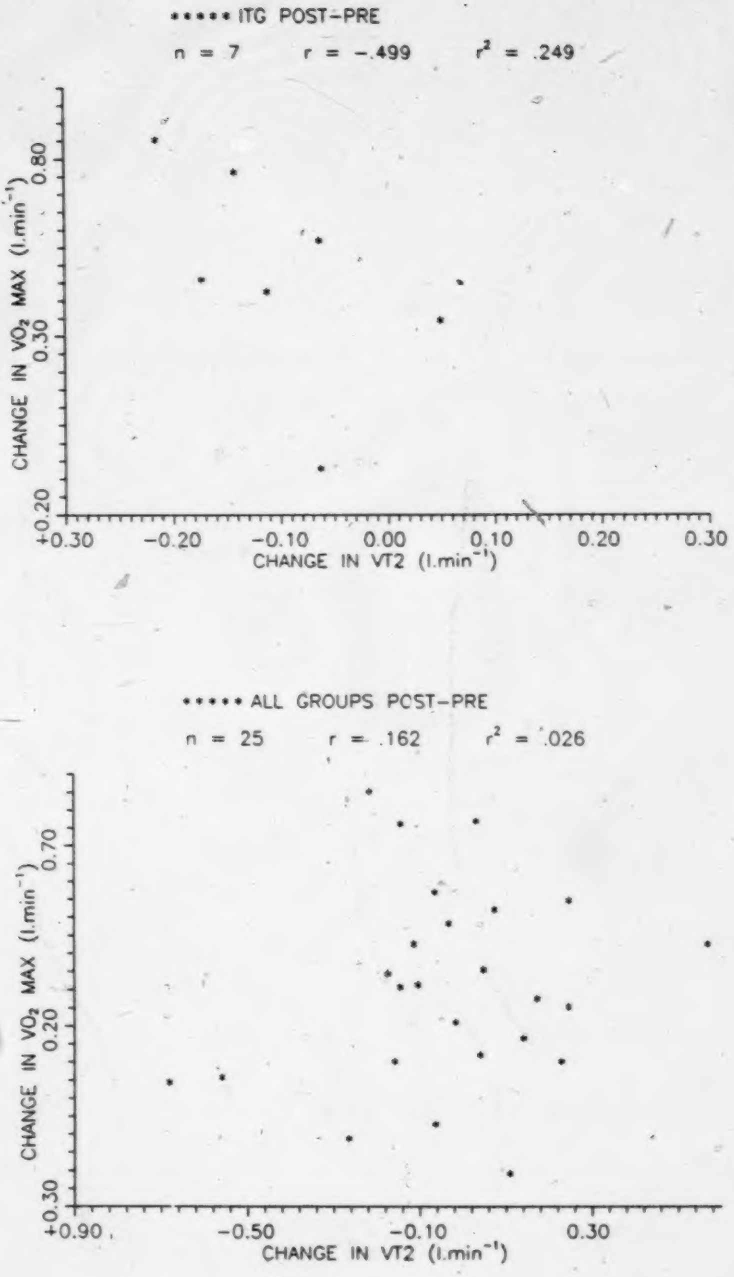


Fig. 10 - Relationship between changes in VO_2 at MEC and VO_2 at the VT2 as a result of training at different exercise intensities (Fig. 10a - ITG; Fig. 10b - all groups).

each separated experimental group and with all subjects pooled together (Figures 9 and 10), did not show a high degree of association. Table 33 presents a summary of the correlations and their coefficients of determination. This dissociation in changes in VO_2 at VT2 and VO_2 max have been shown by several other investigators (Henritze et al., 1985; Gaesser et al., 1984; Smith and O'Donnell, 1984; Denis et al., 1982).

The dissociation in the changes in VO_2 at VT2 and at MEC, may be an important factor to be considered for training purposes. As has been shown by Issekutz et al. (1975), increasing levels of blood lactate may interfere with free fatty acid utilization, and thus progressively reduce the capacity of the body to utilize fat as energy substrate. Alterations in the ventilatory threshold could mean a delay in the increase in lactate concentration. Another important aspect of the dissociation between improvements in VO_2 at the VT2 and MEC is the fact that performance in long distance running events seems to be related to the individual's VT2 (Kumagai et al., 1982) rather than the VO_2 max. The ability to prescribe a specific training intensity that will elicit changes specifically at the threshold point should be considered by exercise physiologists.

Gaesser et al. (1984), observed a nonsignificant increase in VO_2 at VT1 after exercising six male subjects on cycle ergometer for three weeks (six days a week), for thirty minutes, at 70 % of the pretraining VO_2 max. The authors reported that this could be partially explained on the basis that activities of skeletal muscle oxidative enzymes do not change significantly during the first two weeks of training (Houston et al.,1979; Henrickson and Reitman,1977; Ericksson et al.,1972). The present data indicates significant increases in VO_2 at VT2 after three weeks of training continuously at the VT2 or intermittently at 100 % of the VO_2 max, which does not support the explanation by Gaesser et al. (1984). It should be noted however, that when exercise intensity is prescribed based on percent of the VO_2 max, subjects may very well be exercising at different metabolic intensities (i.e. above or below the threshold). This could explain the nonsignificant changes observed by Gaesser and co-workers.

2. V_E, V_E/VO_2, HR, and O_2 Pulse

Changes at the VT2 as result of training were more pronounced in the VTG group than in the two other experimental groups. As the VTG attained VT2 at a higher power output, parallel increases in V_E, VO_2, V_E/VO_2, HR and O_2 pulse were also observed (Tables 16 to 19). Although changes in O_2 pulse were observed as a result of the interval training regimen, these changes seemed to be due solely to an increase in VO_2, because HR at this threshold was unchanged. In contrast, the improvemnents in O_2 pulse in the VTG were attributed to an increase in VO_2 which was accompained by an increase in HR at this threshold. These changes were also related to the significant increase in power output at VT2 for the VTG (20.9 %

higher than the pretest), in contrast to a nonsignificant increase for ITG group (2.6 %).

These findings are in agreement with the report by Bhambhani (1982), which found significant increases in power output and V_E (and VO_2 as well) in the three experimental groups, although no changes were observed in V_E/VO_2. In that study subjects trained continuously on cycle ergometer either at the VT1 or 50 % between VT1 and MEC, and intermittently at 100 % of the VO_2 max.

The present results on O_2 pulse could not be compared because of lack of published data. It should be mentioned that VT2 as a result of training was attained at approximately the same power output (exception for the VTG which increased) and that O_2 pulse significantly increased in the training groups (not significantly in the BVTG). This indicates that training increased the volume of O_2 per heart beat, extracted by the peripheral tissues at submaximal exercise. The same was observed at MEC.

O_2 pulse at VT2 prior to the training program, reached 82.0, 85.2 and 73.4 % of the values observed at MEC for the VTG, BVTG, and ITG groups respectively. As a result of training, the VTG group consistently increased O_2 pulse reaching 87.0 % at the last testing session. No consistent trend was observed in the BVTG and ITG groups.

IV. CONTINUOUS VERSUS INTERVAL TRAINING

Data on maximum oxygen uptake measured at the end of the training program indicated that training continuously at the VT2 (i.e. VTG) or intermittently at 100 % of the VO_2 max (i.e. ITG) elicited significant changes in the participant's aerobic power. The BVTG did not show any significant change in the absolute VO_2 max (4.6 %). Observed changes for the VTG and ITG were in the magnitude of 10.9 and 14.6 % respectively. These percentages are well within previous reported values of 5 to 22 % (Bhambhani and Singh, 1985; Eddy et al.,1976; Fox et al.,1974; Knuttgen et al.,1973; Costill,1970; Sharkey,1970).

Although there have been conflicting reports on which training method is more suitable for increasing VO_2 max (Bryntesow and Sinning, 1973; Pollock et al., 1969; Roskamm, 1967; Cotes and Meade, 1959), the present data did not find significant differences between continuous and interval training methods, for subjects exercising at an intensity requiring a VO_2 similar to their ventilatory threshold or higher. Eddy et al. (1976) found similar results, when their subjects trained continuously at 70 % or intermittently at 100 % of their VO_2 max (1:1 work/rest ratio).

The conflicting results observed in the literature are probably the result of: (1) the different fitness level of the subjects prior to the beginning of the training program; (2) lack of equating the total amount of work per training session for the groups being compared; (3) prescription of exercise intensity based on percent of maximum heart rate or VO_2 max; (4) lack of reassessment of the training intensity, after four weeks of training; (5) data on males and females treated as one group; (6) training device different from the equipment used for test.

It has been suggested that 50 % of the observed increase in VO_2 max as a result of training, can be attributed to enhanced O_2 transport, with the other 50 % due to a possible enhanced O_2 extraction at the tissue level (MacDougall and Sale, 1981; Scheuer and Tipton, 1977; Rowell, 1974).

Interval training seems to be the most suitable method to elicit the greatest degree of muscle hypoxia. The present blood lactate data support this. At the end of the training session, blood ~~lactate~~ concentrations were significantly higher in the ITG group as compared to the VTG or BVTG (Table 26). It is believed by many physiologists that the reduced O_2 levels in the muscle during training, will promote an increase in muscle capillary density (Brodal et al., 1977), an increase in myoglobin (Pattengale and Holloszy, 1967), and an increase in either mitochondrial enzyme activity (Holloszy, 1975) and/or mitochondrial number and size (Hoppeler et al., 1973). The changes in VO_2 max observed as a result of exercising intermittently at 100 % of the subject's VO_2 max seems to be supported by the fact that muscle PO_2 significantly decreases when exercising at this intensity. Muscle PO_2 values drop to about 2 % of the values observed at rest, at sea level, when exercising intermittently at 100 % of the VO_2 max (Astrand and Rodahl, 1979; Saltin et al., 1968; Rahn, 1966). When the intensity is increased to 125 % of the VO_2 max, the PO_2 value does not significantly change (MacDougall and Sale, 1981).

Although interval training using work:relief ratios of 3:3 have been shown to be better for improving VO_2 max (MacDougall, 1981), the 1:1 ratio was selected because of practical reasons. Subjects, particullarly the older ones, seem to feel more confortable with short intervals.

As discussed by MacDougall and Sale (1981) and MacDougall (1977), training continuously at an exercise intensity slightly below the anaerobic threshold (involving a large muscle mass) seems to be the most efficient way of increasing oxygen transport. This would promote a significant alteration in cardiac output, which is the most important factor affecting the ability to transport O_2. The present data support this line of thinking, since the group of subjects that exercised at the VT2 showed a significant increase in their final VO_2 max. The same was not true for the subjects training continuously below this threshold.

V. BODY COMPOSITION ADAPTATIONS AS A RESULT OF TRAINING

Changes in body composition as a result of training, have been extensively examined by exercise physiologists. A 1983 review of the literature by Wilmore indicated that although physical training could be considered an important part of a

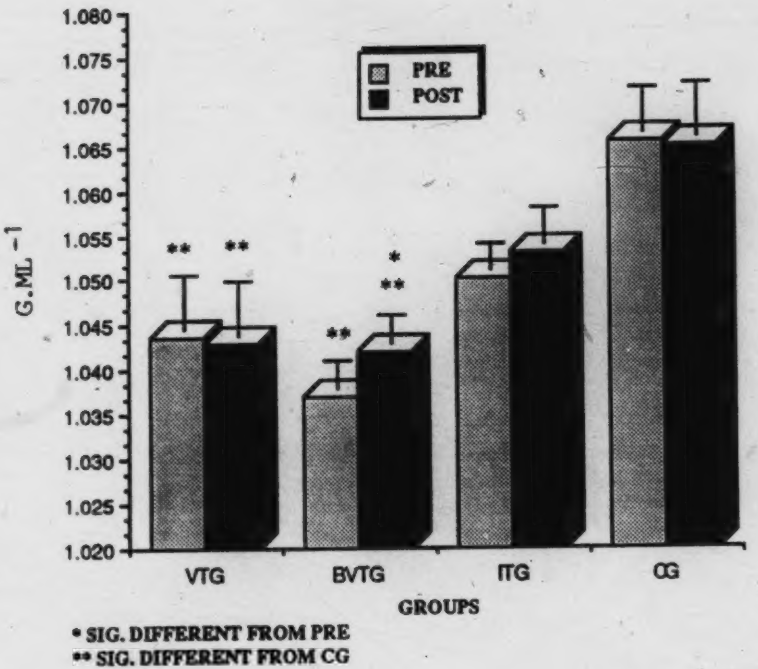


Fig. 11 Changes in body density as a result of training at different exercise intensities.

weight reduction program, changes in body fat were minimal when exercise alone was the independent variable being manipulated (Wilmore, 1983).

Significant alterations in body composition (body weight and density, percent fat, absolute fat and sum of seven skinfolds) were observed as a result of training continuously at an intensity below the ventilatory threshold (Tables 20 to 24). Body weight was reduced by 1.60 kg (1.90 %), body density by 0.00558 $gm.ml^{-1}$ (0.54 %) (Figure 11), percent fat by 2.30 percent points (8.71 %) and sum of seven skinfolds by 9.02 mm (7.46 %).

The observed modifications in body composition could be associated with an elevated metabolic rate after the training session. As reported by Chand and Wenger (1988), VO_2 values during the post-exercise phase increases with time (i.e. the duration of the training session).

The changes in body composition in the present study are within the values reported in the literature as reviewed by Wilmore (1983), for a wide variety of exercise modes.

The present data supports previous reports that exercise alone can reduce body fat (Bjorntorp, 1980; Thompson et al., 1982; Leon et al., 1979; Glick and Kaufmann, 1976; Wilmore et al., 1970), with no necessity of controlling over caloric intake.

Exercising intermittently at 100 % of the VO_2 max and continuously at the ventilatory threshold did not promote any significant changes in body composition.

Considering that there were no significant changes in total energy intake (Table 25), the observed modifications in body composition can be attributed to the training program in which the subjects were enrolled. A close inspection of the data showed both the VTG (8.89 %) and ITG (1.05 %) groups to have reduced non-significantly their total energy intake, while the subjects exercising below the ventilatory threshold group increased non-significantly (4.12 %) their intake. These values were within the normal range recommended for Canadians in the same age group, by the Committee for Revision of the Canadian Dietary Standard, Health and Welfare Canada (Goodhart and Shils, 1980). The present data is also within the range recommended for the North-American population in the same age group, by the Food and Nutrition Board of the National Research Council, Washington D.C. (Goodhart and Shils, 1980).

Pollock et al. (1969) found similar alterations in body composition in a group of middle-aged males as a result of of running/jogging/walking for 30 minutes, 4 times per week, for 16 weeks. No changes were observed in total caloric intake as a result of training. Conflicting results were reported by Johnson et al. (1972). In their study, an increase in body density was accompanied by a decrease in total energy intake when a group of women exercised on cycle ergometer for 30 minutes, 5 days per week, for 10 weeks.

Some cross-sectional studies indicate that active *individuals tend to eat more calories as compared to sedentary ones (Tremblay et al., 1985; Blair et al., 1981; Montoye et al., 1976). Longitudinal studies have shown an increase (Kiens et al., 1980; de Wijn et al., 1979; Parizkova and Poupa, 1963), no change (Titchenal, 1986; Katch et al., 1969; Dempsey, 1964) and decrease (Johnson et al., 1972) in energy intake as a result of a change in the habitual level of physical activity.*

As discussed by Titchenal (1988) "energy intake of humans is generally increased or unchanged in response to exercise. When energy intake increases in response to exercise it is usually below total energy expenditure, resulting in negative energy balance and loss of body weight and fat. Thus, if energy intake is expressed relative to energy expenditure, appetite is usually reduced by exercise" (p.144).

When comparing results from previous reports, it should be noted that most of the studies that looked into the changes in body composition as a result of training, did not assess the subject's total energy intake prior to and following the exercise program.

Glick and Kaufmann (1976) studying a group of male military recruits, observed that changes in body fat (assessed by means of skinfolds) were related to the initial skinfold values. Subjects with higher initial subcutaneous fatfold measurements underwent a larger reduction of body fat at the end of a 6 week training program. Despres et al. (1985) observed a similar relationship between changes in skinfold thickness and initial size in a group of subjects exercising on a cycle ergometer for 20 weeks.

On the contrary, Dempsey (1964) found that neither fat or weight loss was dependent upon initial degree of obesity, when subjects were submitted to 8 weeks of daily training, followed by 5 weeks of normal activity, followed by another 5 weeks of daily activity. There was no control over the amount of physical activity to which the subjects were submitted to, and no assessment of the subjects' energy intake.

The results from the present study, although limited to a potentially biased sample - individuals interested in physical activity - tend to support the very well known fact that exercise induced weight loss (and/or fat loss) has advantage over dieting induced weight reduction programs since the latter is usually accompained by a reduction in lean body mass (Thompson et al., 1982). No changes in LBM were observed in the present data (Table 21).

Considering the fact that the use of skinfold measurements have become very popular among fitness enthusiasts, it seems that it is important to question whether such measurements are sensitive to detect changes as a result of training.

The use of generalized equations as opposed to population specific equations to predict body fat from skinfolds has been extensively discussed in several reports (Sinning et al., 1985; Pollock and Jackson, 1984; Jackson and Pollock, 1982).

Independent of what approach one decides to use, there seems to be a good relationship between the sum of selected skinfolds and body density (Lohman, 1981; Pollock, Smith and Jackson, 1980; Jackson and Pollock, 1978; Durnin and Womersley, 1974; Forsyth and Sinning, 1973; Katch and McArdle, 1973). For the purpose of this discussion the linear model will be addressed, although some authors consider the quadratic regression model a stronger one (Pollock and Jackson, 1984; Jackson and Pollock, 1982).

Pre as well as posttraining data showed high correlation coefficients between the sum of seven skinfolds and body density (-.840 and -.825 respectively) which accounted for approximately 68 to 75 % of the variation (Figure 12). When correlation coefficients were calculated for changes in body density versus changes in the sum of the seven selected skinfolds, a very low 'r' value was obtained (-.215), which could account for only 11 % of the variance between the variables (Figure 13). In summary, changes in body density did not seem to be related to changes in skinfold thickness. When the same correlations were calculated using the sum of the four skinfolds that signifcantly changed (triceps, subscapula, suprailiac and abdomen) with training, the same was observed.

A. Alterations in Subcutaneous Fat Distribution and Total Body Fat as a Result of Training

Training at an intensity below the ventilatory threshold resulted in significant changes in the sum of the seven

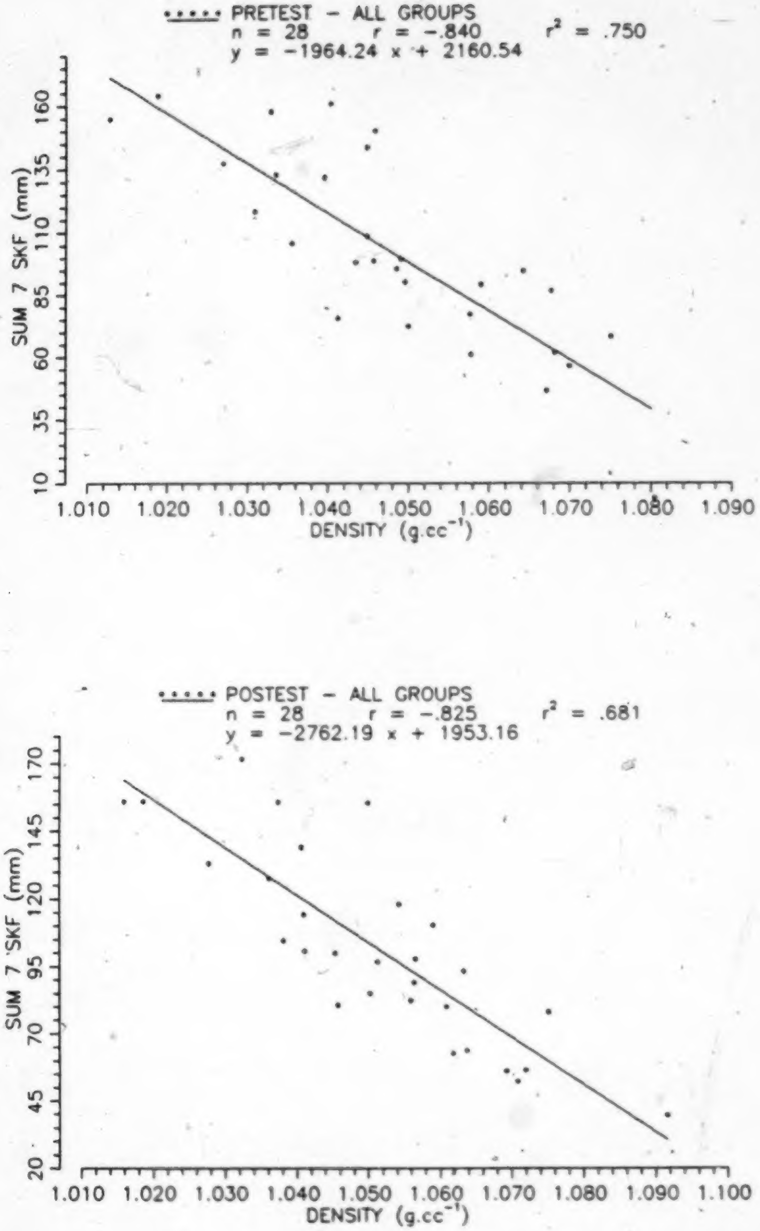


Fig. 12 - Correlation between sum of seven skinfolds and body density prior to the training program and after twelve weeks of training.

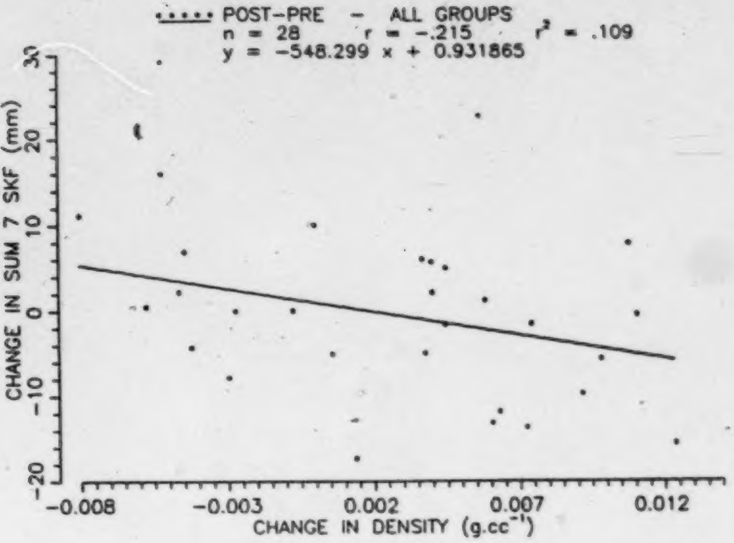
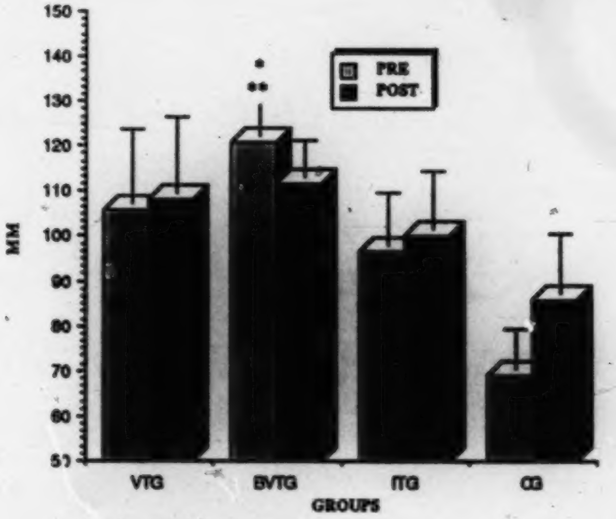


Fig. 13 -- Correlation between changes in the sum of seven skinfolds and changes in body density after twelve weeks of training.

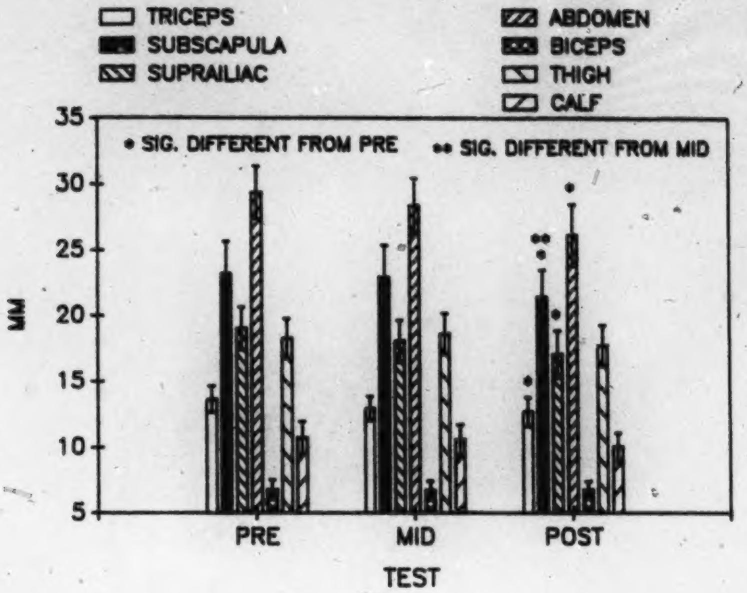


*SIG. DIFFERENT FROM PRE
**SIG. DIFFERENT FROM CG

Fig. 14 - Changes in the sum of seven skinfolds as a result of training at different exercise intensities.

skinfolds measured at selected locations (Figure 14). Specific site modifications were observed at the triceps, subscapular, suprailiac, and abdominal areas (Figure 15). These alterations were not related to the magnitude of the pretraining values. Both the experimental groups exercising either continuously at the VT2 or intermittently at 100 % of the VO_2 max did not demonstrate significant modifications in either the sum of seven skinfolds or at any specific site.

Despres et al. (1985) observed significant changes in the sum of seven skinfolds (same sites as in the present study), as well as in specific sites (abdomen, suprailiac and calf). Percent body fat derived from density measurements was also significantly reduced as a result of training. Percent changes in individual skinfolds (Table 34) in the present study were much lower than the ones reported by Despres et al. (1985). In that study a group of 13 sedentary male subjects exercised continuously (for 45 minutes, at 85 % of the HRR) for a period of 20 weeks, in contrast to the 12 weeks of the present study. Measurements were taken on the subject's left side of the body following the techniques described in International Biological Programme (Weiner and Lourie, 1969). The current training data was obtained on the subject's right side of the body, as recommended by the International Working Group in Kinanthropometric Techniques (Ross and Marfell-Jones, 1982; Ross et al., 1976), and used in the Montreal Olympic Games Anthropological Project - MOGAP. Despres and co-workers (1985)



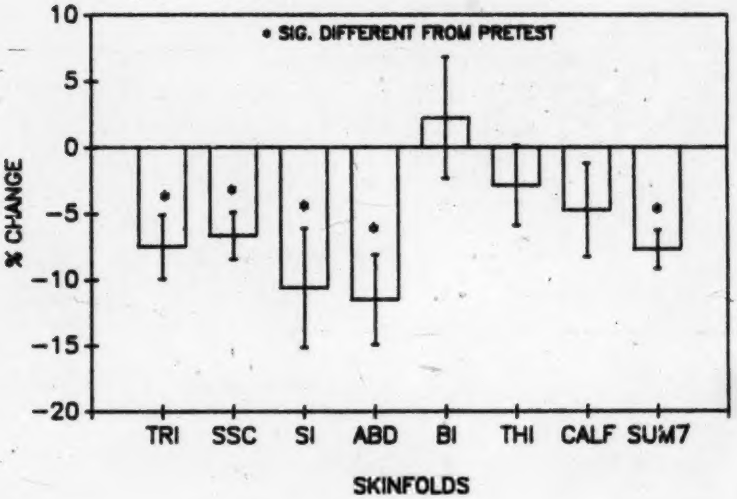


Fig. 15 - Changes in individual skinfolds as a result of training below the ventilatory threshold two.

also reported that the observed modifications were related to the initial level of the fatfold.

In order to compare changes in subcutaneous adiposity with the total body fat, a ratio between the sum of seven skinfolds divided by percent fat (derived from body density) was calculated. The same ratio was also calculated with a correction for the double skin layer which is equal to 4 mm (Allen et al., 1956). A total of 28 mm were subtracted from the sum of the seven skinfolds measured. Although in the BVTG a significant reduction in body fat was observed, no changes in the uncorrected or corrected ratios (Tables 35 and 36) were observed in the three experimental groups (the CG increased significantly). These observations seem to be in agreement with the findings by Despres et al. (1985) for the uncorrected ratio, but in contrast with the results for the corrected one.

The present results suggest that exercise alone can be effective in reducing total body fat, as shown by changes in body density. The reduction in body fat seemed to have happened also at the subcutaneous fat stores as shown by changes in the sum of skinfolds, although these changes did not seem to be related to the changes in total body fat. This was evidenced by the fact that the ratio of the sum of seven skinfolds over % body fat (derived from density) did not show any significant change. Other evidence was the fact that changes in body density did not correlate highly with changes in the sum of either seven or four skinfolds.

As has been shown by Borkan et al. (1982) and confirmed by Davies et al. (1986) there is a variability between internal and subcutaneous fat. The report from Davies et al. (1986) indicated that subcutaneous and internal fat masses correlated poorly for both men ($r = .05$) and women ($r = -.01$). Changes in body fat observed as a result of reduction in subcutaneous skinfolds, and predictions of body fat based on measurements of fatfolds should be viewed with skepticism.

VI. BLOOD LACTATE AND FFA CONCENTRATIONS DURING TRAINING AT DIFFERENT EXERCISE INTENSITIES

One of the purposes of this study was to observe the interrelationship between blood lactate and FFA concentrations during different exercise intensities and changes in body density resulting from training at those intensities.

Twice during this study, venous blood was collected at rest, midway and immediately after the cessation of a training session. Blood samples were analyzed for both lactate and FFA concentrations.

It has been previously suggested that training at an intensity below the anaerobic threshold would likely increase the utilization of FFAs as the main fuel source (Tanaka et al.,1987). The FFAs are mobilized from adipose tissue and plasma triglycerides and then oxidized by the working muscles in relation to their concentration in the blood. When exercise is performed at a higher intensity (i.e. above the anaerobic threshold) there is a tendency towards the inhibition of the release of FFA from lipid depots, thereby supressing their oxidation and increasing the relative rate of the utilization of carbohydrates. Exercising above the anaerobic threshold is usually accompanied by a significant increase in lactate concentration in the blood. The classical explanation is that the contracting muscle is O_2 deficient and therefore part of the energy requirement must be supplemented through increased lactate production (Hill et al., 1924). Numerous studies support that lactate formation in dependent on O_2 availability (Katz and Sahlin, 1987; Hogan and Welch, 1986; Rowell et al., 1984; Woodson et al., 1978; Linnarsson et al., 1974).

As shown experimentally in man by Boyd et al. (1974), "during exercise a rise in arterial levels of plasma lactate or pyruvate, or both, inhibits the release of FFAs and glycerol from the adipose tissue" (p. 539). Decreases in plasma FFAs have been show as a result of sodium lactate infusion in the resting dog (Miller et al., 1963; Issekutz and Miller, 1962), and on the fasting rat (Houghton et al., 1971). Cobb and Johnson (1963) showed that there was an inverse relationship between the level of lactate produced and the level of circulating FFAs.

Lactate concentrations at the beginning of the study significantly increased in all groups during exercise with post values being significantly different from resting concentrations. The final lactate concentration in the ITG was significantly higher than the VTG and BVTG, with the BVTG being *significantly different from the VTG. At the end of the study similar increases were observed by all groups. No differences were observed for the three groups, at the different conditions, when values measured at the beginning of the study were compared to the postest (Figure 17). The lack of difference between pre and posttest due to training, was not surprising since subjects at the end of study did exercise at a higher power output when compared to the beginning of the training program.*

Samples taken at the beginning of the study showed FFA to increase significantly at the end of exercise in the BVTG (different from VTG also), but did not change in the VTG and ITG. End of the study samples showed the same trend, but with no difference between the groups at the three conditions. No differences were observed between the beginning and end of the study data (Figure 18).

Lactate and FFA concentrations observed during training at the different exercise intensities were well within previous reported values (Ribeiro et al., 1986; Schnabel et al., 1982; Stegmann and Kindermann, 1982).

The results of the present study did not show any relationship between the changes in blood lactate and FFA during all three training intensities (Tables 28 and 29). This is in aggreement with the report by Ribeiro et al. (1986) which exercised eight male subjects at exercise intensities below and above the anaerobic threshold. Schnabel et al. (1982) exercised 12 Physical Education students at their individual anaerobic

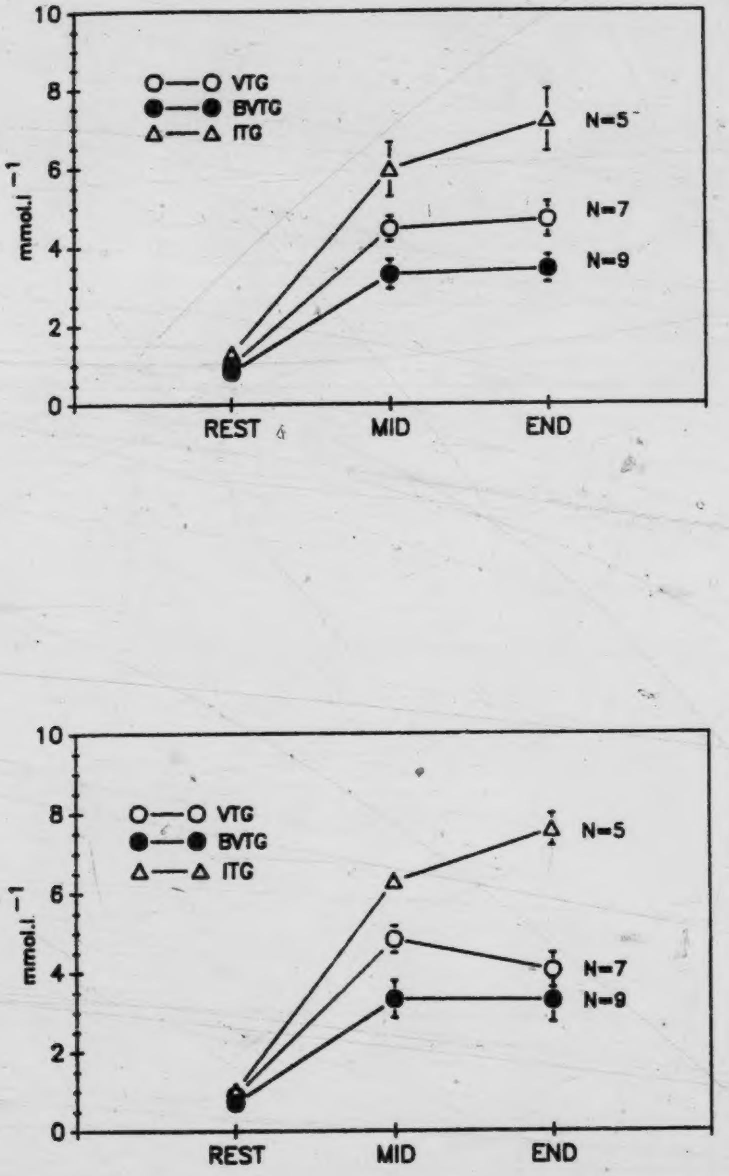


Fig. 16 - Changes in plasma lactate concentration during training at different exercise intensities. Fig. 16a - at the beginning of the study; Fig. 16b - at the end of the study.

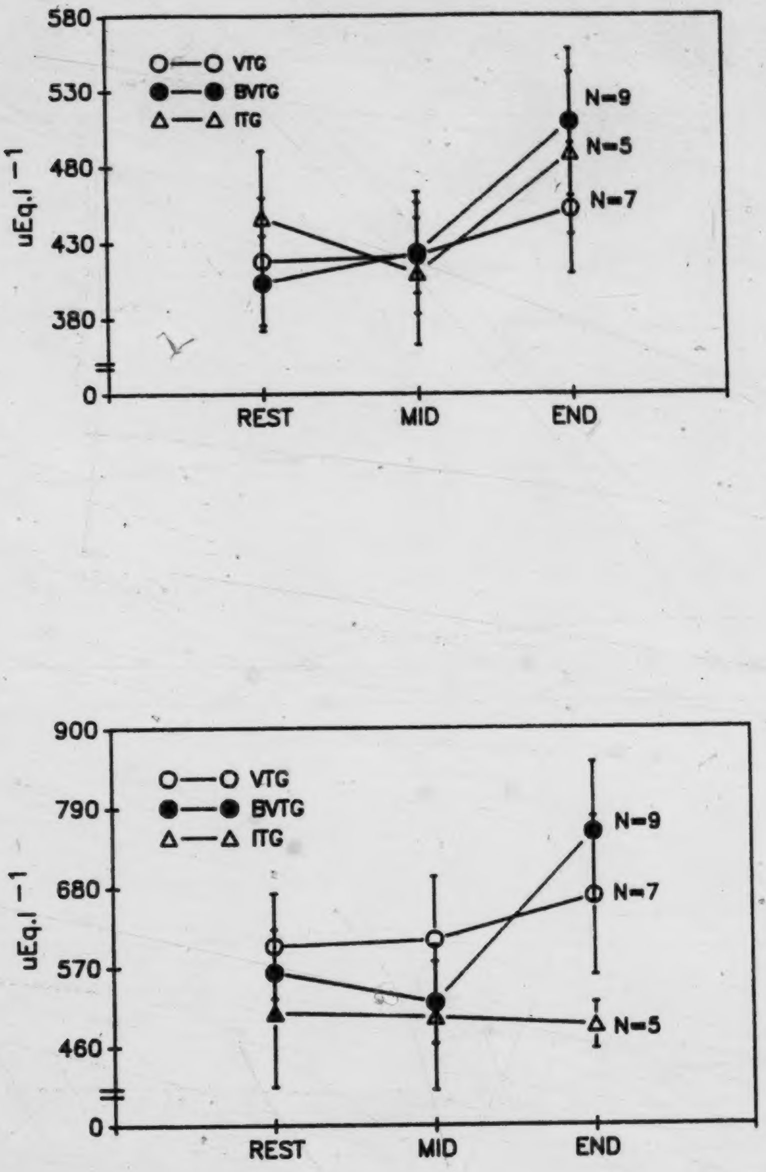


Fig. 17 - Changes in plasma FFA concentration during training at different exercise intensities. Fig. 17a - at the beginning of the study; Fig. 17b - at the end of the study.

threshold (IAT) for 50 minutes and observed that increase in lactate concentration did not result in depression of the level of circulating FFA in the blood. IAT was defined as the maximal exercise intensity that was tolerated without a progressive lactate accumulation.

FFA values in the study by Schnabel et al. (1982) and Ribeiro et al. (1986) should be viewed with caution since subjects fasted for only three and eight hours respectively. Ideally subjects should fast for at least 12 hours prior to testing time, and should avoid drinking beverages containing caffeine if FFA determinations are to be made. Most of the studies reviewed have use a 12 to 18 hour fasting period (Blatchford et al., 1985; Ahlborg et al., 1976; Boyd et al., 1974; Havel et al., 1967).

No significant relationships were observed between the increase in FFA and changes in body density in all training groups at pre and posttest (Table 37). Correlation coefficients between changes in FFA concentration and changes in the sum of seven skinfolds were also low (Table 38), with the exception for the BVTG at pretest ($r = .788$).

Tanaka et al. (1987) observed significant changes in percent body fat a a result of training at the lactate threshold for 60 minutes. VO_2 at the lactate threshold and VO_2 max were also significantly increased as a result of the training program which was maintained for four months. During the exercise session FFA was reported to have increased linearly at pretest. A slight decrease below resting values up to 30 minutes of exercise with a subsequent increase at 60 minutes in the posttest condition was observed. Surprisingly, no values were reported. Lactate concentration was maintained at very low levels (1.2 to 1.6 $mmol.l^{-1}$).

Yoshitake et al. (1987) also observed low lactate values (2.01 ± 0.93 $mmol.l^{-1}$) with a twofold increase in FFA concentration when 16 healthy females exercised at an intensity reported as being at the lactate threshold level.

Data from Tanaka's and Yoshitake's studies have to be interpreted with restrictions, since the authors did not provide enough methodological detail, such as how many hours of fasting the subjects had prior to the testing session, or how the data was analyzed.

In summary, the results from the present study do not support that elevated levels of lactate may inhibit FFA turnover as has been demonstrated experimentally by others (Issekutz et al, 1975; Boyd et al.,1974). As mean lactate values at the end of exercise were not over 8 $mmol.l.^{-1}$, a possible explanation would be that FFA is not depressed unless lactate concentration reaches a critical level. This critical level may also be individually different.

FFA concentrations did not show an abrupt increase during exercise, particularly in the VTG group, which was exercising below the ventilatory threshold. Since lactate concentrations were not over 4 $mmol.l^{-1}$ in the BVTG, the failure in *increasing FFA to higher levels can only be speculated. As discussed by Ribeiro et al. (1986) an "... increase in serum glycerol without changes in serum FFA concentration may reflect stimulation of muscle lipolysis and utilization of endogenous triglycerides as fuel, since hepatic uptake of glycerol is increased at higher exercise intensities, despite reduction in hepatic blood flow" (p.219).*

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

I. SUMMARY

The objectives of this study were: (1) to find the best training intensity - among two continuous and one intermittent - that promoted a significant increase in body density and an increase in VO_2 max in an active non-athletic male sample; (2) to observe which of the three training intensities was the most effective in increasing oxygen consumption at the VT2, and how it related to modifications in the VO_2; (3) to observe how subcutaneous fat (skinfolds) at selected sites of the body responded to the three training programs, and how this change was related to the alterations in body density; (4) to observe the interrelationships between the FFA and LA concentrations in the blood during training, and changes in body density which resulted from the three training intensities.

Thirty-three individuals were subjected to an initial progressive maximum exercise capacity test on an electromagnetically braked cycle ergometer. Throughout the exercise test gas exchange measurements were continuously monitored. The ventilatory threshold two (VT2) was determined as the VO_2 (in l/min) at the power output at which the V_E/VO_2 ratio reached a minimum and F_ECO_2 reached a maximum. Prior to the beginning of the study, the test/retest reliability of the ventilatory threshold two was found to be highly reproducible, when a group of active male subjects were tested twice, a week apart.

Based on the initial maximum exercise capacity test the subjects were ranked in descending order according to their relative VO_2 max (ml/kg/min). They were then randomly assigned into three experimental exercising groups: (1) VTG - which trained continuously at a power output requiring an oxygen consumption similar to that observed at the ventilatory threshold two; (2) BVTG - which trained continuously at a power output requiring an oxygen consumption which was 15 % below that observed at the ventilatory threshold two; and (3) ITG - which trained intermittently at a power output similar to the maximal oxygen consumption (100 % VO_2 max). The training intensity was established during the initial exercise testing. This resulted in a stratified random sample with eleven subjects in each group. In addition, six volunteers were submitted to the same testing protocol and were assigned to a non-exercising control group.

All subjects were then submitted to a protocol of anthropometric measurements which included the following: (1) height; (2) weight; (3) seven skinfolds measurements (triceps, subscapula, suprailiac, abdomen, biceps, thigh and calf); and (4) measurement of body density. All measurements were taken by the same investigator.

The same exercise testing and anthropometric protocol was repeated at the end of twelve weeks. In addition to this, the experimental group was submitted to the anthropometric protocol at week eight.

The three experimental groups exercised for twelve weeks, three times a week, for at least twenty minutes. The total amount of work per training session was equated among the groups. The training intensity was reassessed every ninth training session, at weeks three, six and nine.

During the course of the study a nutritional assessment was conducted in all experimental subjects by means of nutritional recall diaries. Total caloric intake was assessed with the data being analyzed by an experienced nutritionist utilizing the Kelloggs/University of Alberta database.

The study comprised the following experimental designs: (1) a two-factor design in which Factor A had four levels, namely the control, and the three experimental groups, and Factor B had two levels namely the Pre and Post training values of selected physiological variables; (2) a two-factor design in which Factor A had three levels, namely the three experimental groups, and Factor B had three levels namely the Pre, MID and Post training values of selected physiological variables; (3) a three-factor design in which Factor A had three levels, namely the three experimental groups, Factor B had two levels, namely the two testing sessions, and Factor C had two levels, namely the tenth and twentieth minutes of exercise where the variables were collected; (4) a two-factor design in which Factor A had three levels, namely the three experimental groups, and Factor B had five levels, namely the five testing sessions. The computer program "Statistical Package for the Social Sciences -SPSS X" with the user procedure UANOVA written by Terry Taerum (unpublished) at the University of Alberta Computer Services, was utilized for the analysis of the data.

II. CONCLUSIONS

Based on the findings, and within the limitations of this study, the following conclusions were drawn:

(1) Power output (kpm/min) significantly increased in the three experimental groups (VTG, BVTG, ITG) but decreased in the control group (CG). Changes in power output did not occur until six weeks of training.

(2) Absolute VO_2 max increased significantly in the VTG and ITG, but did not change significantly in the BVTG and CG. When VO_2 max was expressed relative to body weight, all training groups (VTG, BVTG and ITG) showed significant increases. Relative VO_2 max in the VTG and ITG was significantly altered after three weeks of training, but only changed for the BVTG after nine weeks.

(3) Power output at the ventilatory threshold two (VT2) significantly increased only in the VTG.

(4) VO_2 (l/min or ml/kg/min) at VT2 significantly increased in the VTG and ITG as a result of training, but changed in the BVTG.

(5) Changes in VO_2 max were not correlated to changes in VO_2 at VT2. This dissociation was observed when correlations were computed for each individual group or to the pooled data (all groups).

(6) The BVTG showed significant alterations in body composition. Body weight, percent body fat, absolute fat (in kg), and sum of seven skinfolds were significantly reduced as a result of training. Body density was significantly increased in the same group. Both the VTG or the ITG did not show any modifications in body composition as a result of training.

(7) Changes in body composition seemed to be due to the exercise program since subjects did not alter significantly their nutrition intake (kcal) during the the twelve weeks of the training study.

(8) Although changes in subcutaneous as well as total body fat were observed in the BVTG as a result of training, these changes did not seem to be related.

(9) Changes in subcutaneous fat were more pronounced in the triceps, subscapula, suprailiac and abdominal areas, in the BVTG group.

(10) Changes in blood lactate and FFA concentration were not related, when subjects exercised at the different exercise intensities.

(11) No significant relationships were observed between the increase in FFA concentration during training (pre or posttest) and changes in body density.

(12) A significant correlation between FFA concentration and reduction in the sum of skinfolds was observed in the BVTG at pretest but not at posttest.

III. RECOMMENDATIONS

It is recommended that effects of training on body composition should be studied in both males and females over a longer period of time. Both interval and continuous training modes should be studied, at different intensities and durations. Changes in subcutaneous fat should be investigated with the aid of more sophisticated techniques, such a fat biopsy or nuclear magnetic resonance in order to more precisely answer questions related to the type of changes occurring as a result of training (i.e. change in size and/or number of fat cells). The relationship between blood lactate and FFA concentration should be further investigated by taking additional blood samples after the cessation of exercise (i.e. immediately after, five, ten, twenty, thirty and sixty minutes after cessation of exercise).

BIBLIOGRAPHY

Acheson,K.J.; Campbell,I.T.; Edholm,O.G.; Miller,D.S. and Stock,M.J. (1980). The measurement of food and energy intake in man - an evaluation of some techniques. American Journal of Clinical Nutrition, 33:1147-1154.

Adams,W.C.; McHenry,M.M. and Bernauer,E.M. (1974). Long-term physiologic adaptations to exercise with special reference to performance and cardiorespiratory function in health and disease. American Journal of Cardiology, 33:765-775.

Ahlborg,G.; Hagenfeldt,L. and Wahren,J. (1976). Influence of lactate infusion on glucose and FFA metabolism in man. Scandinavian Journal of Clinical Laboratory Investigation, 36:193-201.

Ahrens,S.J. (1971). Statistical tests of significance: truth, paradox, or folly ? Research Quarterly, 42(4):437-440.

Allen,T.H.; Peng,M.T.; Chen,K.P.; Huang,T.F.; Chang,C. and Fang,H.S. (1956). Prediction of total adiposity from skinfolds and the curvilinear relationship between external and internal adiposity. Metabolism, 5:346-352.

Allison,T.G.; Lammarino,R.M.; Metz,K.F.; Skrinar,G.S.; Kuller,L.H.; Robertson,R.J. (1981). Failure of exercise to increase high density lipoprotein cholesterol. Journal of Cardiac Rehabilitation, 1:257-265.

American College of Sports Medicine. (1978). American College of Sports Medicine position statement on the recommended quantity and quality of exercise for developing and maintaining fitness in healthy adults. Medicine and Science in Sports, 10(3):VII-IX.

Astrand,P.O. and Rodahl,K. (1970). Textbook of Work Physiology. New York: McGraw-Hill.

Astrand,P.O. and Rodahl,K. (1986). Textbook of Work Physiology. McGraw-Hill, 2nd Edition, New York.

Aunola,S. and Rusko,H. (1984). Reproducibility of aerobic and anaerobic thresholds in 20-50 year old men. European Journal of Applied Physiology, 53:260-266.

Anuola,S. and Rusko,H. (1986). Aerobic and anaerobic thresholds determined from venous lactate or from ventilation and gas exchange in relation to muscle fiber composition. International Journal of Sports Medicine, 7:161-166.

Banister,E.W.; Taunton,J.E.; Patrick,T.; Oforsagd,P.; Duncan,W.R. (1970). Effect of oxygen at high pressure at rest and during severe exercise. Respiratory Physiology, 10:74-84.

Beaver,W.L.; Wasserman,K.; Whipp,B.J. (1986). A new method for detecting anaerobic threshold by gas exchange. Journal of Applied Physiology, 60(6):2020-2027.

Becker,D.M. and Vaccaro,P. (1983). Anaerobic threshold alterations caused by endurance training in young children. Journal of Sports Medicine, 23:445-449.

Beshers,J. (1958). On "A critique of test of significance in survey research". American Sociological Review, 23:199.

Bhambhani,Y. (1982). Ventilatory Thresholds During a Graded Exercise Test: The Effects of Three Training Intensities in Males. Unpublished Doctoral Dissertation, University of Alberta, Canada.

Bhambhani,Y. and Singh,M. (1985a). Ventilatory thresholds during a graded exercise test. Respiration, 47:120-128.

Bhambhani,Y. and Singh,M. (1985b). Effects of three training intensities on VO2 max and Ve/VO2 ratio. Canadian Journal of Applied Sport Sciences, 10(1):44-51.

Bhambhani,Y.; Singh,M. and Gomes,P. (1987). Equivalent changes in VO_2 max and percent body fat subsequent to continuous and interval training. Medicine and Scinece in Sports and Exercise, 19(2):S88.

Bhambhani,Y.; Singh,M., Turner,A. (1983). Effects of training on ventilatory thresholds during a graded exercise test. Proceedings of FISU Conference, Universiade'83. pp:906-921, Canada.

Bjorntorp,P. (1980). Results of conservative therapy of obesity: correlation with adipose tissue morphology. American Journal of Clinical Nutrition, 33:370-375.

Bjorntorp,P. (1965). The effect of lactic acid on adipose tissue metabolism in vitro. Acta Medica Scandinavica, 178:253-255.

Bjorntorp,P.; Carlgren,G.; Isaksson,B.; Krotkiewski,M.; Larsson,B.; Sjostrom,L. (1975). Effect of an energy-reduced dietary regimen in relation to adipose tissue cellularity in obese women. American Journal of Clinical Nutrition, 28:445-452.

Bjorntorp,P.; Grimby,G.; Sanne,H.; Sjostrom,L.; Tibblin,G.;

Wlhelmsen,L. (1972). Adipose tissue fat cell size in relation to metabolism in weight-stable, physically active men. Hormonal Metabolism Research, 4:178-182.

Black,A.; Ribeiro,J.P.; Bochese,M.A. (1984). Effects of previous exercise on the ventilatory determination of the anaerobic threshold. European Journal of Applied Physiology, 52:315-319.

Blair,S.N.; Ellsworth,N.M; Haskell,W.L.; Stern,M.P. and Farquhar,J.W. (1981). Comparison of nutrient intake in middle-aged men and women runners and controls. Medicine and Science in Sports and Exercise, 13:310-315.

Blatchford,F.K.; Knowlton,R.G. and Schneider,D.A. (1985). Plasma FFA responses to prolonged walking in untrained men and women. European Journal of Applied Physiology, 53:343-347.

Boileau,R.A.; Buskirk,E.R.; Hortsman,D.H.; Mendez,J.; Nicholas,W.C. (1971). Body composition changes in obese and lean men during physical conditioning. Medicine and Science in Sports, 3:183-189.

Boning,D.; Gonen,Y.; Maassen,N. (1984). Relationship between workload, pedal frequency, and physical fitness. International Journal of Sports Medicine, 5:92-97

Booth,M.A.; Booth,M.J.; Taylor,A.W. (1973). Effects of endurance training upon fat cell size and number in rats. In: The Appliccation of Science and Medicine to Sport, A. W. Taylor (Ed.). C. C. Thomas, Spirngfield,Ill., pp. 263-270.

Borkan,G.A.; Hults,D.E.; Cardarelli,J. and Burrows,B.A. (1982). Comparison of ultrasound and skinfold measurements in assessmentof subcutaneous and total fatness. American Journal of Physical Anthropology, 58:307-313.

Bosu,A.; Passmore,R.; Strong,J.A. (1960). The effect of exercise on the level of non-esterified fatty acids in the blood. Quarterly Journal of Experimental Physiology, 45:312-317.

Bradley,B.L.; Mestas,J.; Forman,J. and Unger,K.M. (1980). The effect of respiratory drive of a prolonged physical conditioning program. American Review of Respiratory Diseases, 122:741-746.

Brodal,P.; Ingjer,F. and Hermansen,L. (1977). Capillary supply of skeletal muscle fibers in untrained and endurance-trained men. American Journal of Physiology, 232:705-712,

Brooks,G.A. (1985a). Response to Davis' manuscript. Medicine and Science in Sports and Exercise, 17(1):19-21.

Brooks,G.A. (1985b). Anaerobic threshold: review of the concept and directions for future research. Medicine and Science in Sports and Exercise, 17(1):22-31.

Brooks,G.A. (1986). The lactate shuttle during exercise and recovery. Medicine and Science in Sports and Exercise, 18(3):360-368.

Brooks,G.A. and Fahey,T.D. (1984). Exercise Physiology - Human Bioenergetics and Its Applications. New York: John Wiley & Sons.

Brooks,G.A.; Stanley,W.C.; Gertz,E.W.; Wisneski,J.A.; Morris,D.L. and Neesi,R.A. (1985a). Lactate metabolism in exercising human skeletal muscle: evidence for lactate extraction during net lactate release. (Abstract). Federation Proceedings, 44:1013.

Brooks,G.A.; Stanley,W.C.; Gertz,E.W.; Wisneski,J.A.; Morris,D.L. and Neesi,R.A. (1985b). Systemic lactate kinetics during graded exercise in man. (Abstract). Medicine and Science in Sports and Exercise, 17:206.

Brown,C.H. and Wilmore,J.H. (1974). The effects of maximal resistance training on the strength and body composition of women athletes. Medicine and Science in Sports, 6:174-177.

Brozek,J. (1952). Changes in body composition in man during maturity and their nutritional implications. Federation Proceedings, 11:784-793.

Brozek,J. and Keys,A. (1953). Geriatrics, 8:70-75.

Brozek,J.; Grande,F.; Anderson,J. and Keys,A. (1963). Densitometric analysis of body composition: revision of some quantitative assumptions. Annals of the New York Academy of Sciences, 110:113-140.

Bryntesow,P. and Sinning,W.E. (1973). The effects of train-frequencies on the retention of cardiovascular fitness. Medicine and Science in Sports, 5:29-33.

Buchanan,M. and Weltman,A. (1985). Effects of pedal frequency on VO2 and work output at lactate threshold (LT) fixed blood lactate concentration of 2 mM and 4 mM, and max in competitive cyclists. International Journal of Sports Medicine, 6:163-168.

Bunc,V.; Sprynarova,S.; Zdanowicz,R. (1986). Comparison of the anaerobic threshold and mechanical efficiency of running in young and adult athletes. International Journal of Sports

Medicine, 7:156-160.

Buskirk,E.R.; Thompson,R.H.; Lutwak,L.; Whedon,G.O. (1963). Energy balance in obese patients during weight reduction: influence of diet restriction and exercise. Annals of the New York Academy of Sciences, 110:918-940.

Caiozzo,V.J.; Davis,J.A.; Ellis,J.F.; Azus,J.L.; Vandagriff,R.; Prietto,C.A.; McMaster,W.C. (1982). A comparison of gas exchange indices used to detect the anaerobic threshold. Journal of Applied Physiology, 53(5):1184-1189.

Carlson,L.A. and Pern[illegible],B. (1959). Studies on blood lipids during exercise. I. Arterial and venous plasma concentrations of unesterified fatty acids. Journal Laboratory Clinical Medicine, 39:833-841.

Carter,J.E.L. and Phillips,W.H. (1969). Structural changes in exercising middle-aged males during a 2-year period. Journal of Applied Physiology, 27:787-794.

Chad,K.E. and Wenger, H.A. (1988). The effects of exercise duration on the exercise and post-exercise oxygen consumption. Canadian Journal of Applied Sport Sciences, 13(4):204-207.

Christensen,T. and Christensen,G. (1978). The effect of blood loss on the performance of physical exercise. European Journal of Applied Physiology, 39:17-25.

Christiansen,J.; Douglas,C.G.; Haldane,J.S. (1914). The absorption and dissociation of carbon dioxide by human blood. Journal of Physiology (London), 48:244-271.

Chumlea,W.C.; Roche,A.F.; Siervogel,R.M.; Knittle,J.L.; Webb,P. (1981). Adipocytes and adiposity in adults. American Journal of Clinical Nutrition, 34:1798-1803.

Clarkson,P.M.; Katch,F.I.; Kroll,W.; Lane,R.; Kamen,G. (1980). Regional adipose cellularity and reliability of adipose cell size determination. American Journal of Clinical Nutrition, 33:2245-2252.

Cobb,L.A. and Johnson,W.P. (1963). Hemodynamic relationships of anaerobic metabolism and plasma fatty acids during prolonged, strenuous exercise in trained and untrained subjects. Journal of Clinical Investigation, 42:800-810.

Conconi,F.; Ferrari,M.; Ziglio,P.G.; Droghetti,P.; Codeca,L. (1982). Determination of the anaerobic threshold by a noninvasive field test in runners. Journal of Apllied Physiology, 52:869-873.

Collins,W.E. Clinical Spirometry and Braintree,M.A. (1967). Warren E. Collins, Inc.:12-15.

Cornett,R.J.; Gayeski,T.E.L.; Honig,C. (1984). Lactate accumulation in fully aerobic working, dog gracilis muscle. American Journal Physiology, 246: 15:H120-H128.

Costill,D.L. (1970). Metabolic responses during distance running. Journal of Applied Physiology, 28:251-255.

Costill, D.L.; Fink,W.J.; Getchell,L.H. (1979). Lipid metabolism in skeletal muscle of endurance-trained males and females. Journal of Applied Physiology, 47:787-791.

Cotes,J. and Meade,F. (1959). Physical training in relation to energy expenditure of walking and to factors controlling respiration during exercise. Ergonomics, 2:195-206.

Cunningham,D.A.; McCrimmon,D.; Vlach,L.F. (1979). Cardiovascular response to interval and contiuous training in women. European Journal of Applied Physiology, 41:187-197.

Davies,C.T.M. and Knibbs,A. (1971). The training stimulus: the effects of intensity, duration and frequency on max aerobic power output. International Z. Arbeit Physiology, 29:299-304.

Davies,C.T.M. and Sargeant,A.J. (1975). Effects of training on the physiological responses to one- and two-leg work. Journal of Apllied Physiology, 38(3):377-381.

Davies,P.S.W.; Jones,P.R.M. and Norgan,N.G. (1986). The distribution of subcutaneous and internal fat in man. Annals of Human Biology, 2:189-192.

Davis,H.A. and Gass,G.C. (1981). The anaerobic threshold as determined before and during lactic acidosis. European Journal of Applied Physiology, 47:141-149.

Davis,J.A.; Frank,M.H.; Whipp,B.J.; Wasserman,K. (1979). Anaerobic threshold alterations caused by endurance training in middle aged men. Journal of Applied Physiology, 46:1039-1046.

Davis,J.A.; Caiozzo,V.J.; Lamarra,N.; Ellis,J.F.; Vandagriff,R.; Prietto,C.A.; McMaster,W.C. (1983). Does the gas exchange anaerobic threshold occur at a fixed blood lactate concentration of 2 or 4 mM ? International Journal of Sports Medicine, 4(2):89-93.

Davis,J.A; Frank,M.A.; Whipp,B.J. and Wasserman,K. (1979). Anaerobic threshold alterations caused by endurance training in middle-aged men. Journal of Applied Physiology, 46:1039-1046.

Davis,J.A.; Vodak,P.; Wilmore,J.H.; Vodak,J.; Kurtz,P. (1976). Anaerobic threshold and maximal aerobic power for three modes of exercise. *Journal Applied Physiology*, 41(4):544-550.

Davis,J.A. Whipp,B.J.; Lamarra,N.; Huntsman,D.J.; Frank,M.H.; Wasserman,K. (1982). Effect of rampslope on determination of aerobic parameters from the ramp exercise test. *Medicine and Science in Sports and Exercise*, 14:339-343.

De Lanne,R.; Barnes,J.R.; Brouha,L.; Massart,F. (1959). Changes in acid-base balance and blood gases during muscular activity and recovery. *Journal of Applied Physiology*, 14:328.

Dempsey,J.A. (1964). Anthropometrical observations on obese and non-obese young men undergoing aprogram of vigorous physical exercise. *Research Quarterly*, 35:275-287.

Denis,C; Dormois,D.; Castells,J.; Bonnefoy,R.; Padilla,S.; Geyssant,A. and Lacour,J.R. (1988). Comparison of incremental and steady state tests of endurance training. *European Journal of Apllied Physiology*, 57:474-481.

Denis,C; Dormois,D.; Lacour,J.R. (1984). Endurance training, VO_2 max, and OBLA; a longitudinal study of two different age groups. *International Journal of Sports Medicine*, 5:167-173.

Denis,C.; Fouquet,R.; Poty,P.; Geyssant,A. and Lacour,J.R. (1982). Effects of 40 weeks of endurance training on the anaerobic threshold. *International Journal of Sports Medicine*, 3:208-214.

Despres,J.P.; Bouchard,C.; Bukowiecki,L.; Savard,R.; Lupien,J. (1983). Morphology and metabolism of human fat cells: a reliability study. *International Journal of Obesity*, 7:231-240.

Despres,J.P.; Bouchard,C.; Savard,R.; Tremblay,A.; Marcotte,M.; Theriault,G. (1984a). Effects of exercise-training and detraining on fat cell lipolysis in men and women. *European Journal of Applied Physiology*, 53:25-30.

Despres,J.P.; Bouchard,C.; Savard,R.; Tremblay,A.; Marcotte,M.; Theriault,G. (1984b). The effect of a 20-week endurance training program on adipose-tissue morphology and lipolysis in men and women. *Metabolism*, 33(3):235-238.

Despres,J.P.; Bouchard,C.; Tremblay,A.; Savard,R.; Marcotte,M. (1985). Effects of aerobic training on fat distribution in male subjects. *Medicine and Science in Sports and Exercise*, 17(1):113-118.

de Wijn,J.F.; Levsink,J. and Post,G.B. (1979). Diet, body composition and physical conditionin of champion rowers during periods of training and out of training. Bibliotheca Nutritio et Dieta, 27:143-148.

Dieterle,P.; Dieterle,C.; Botterman,P.; Schwarzk,K.; Henner,J. (1969). In vitro versuche zur antilipolytischen wirkung von milchsaure. Diabetologia, 5:238-242.

Dolgener,F.A. and Brooks,W.B. (1978). The effects of interval and continuous training on VO_2 max and performance in the mile run. Journal of Sports Medicine and Physical Fitness, 18:345-352.

Donovan,C.M. and Brooks,G.A. (1983). Endurance training effects lactate clearance, not lactate production. American Journal of Physiology, 244:E83-E92.

Douglas,C.G. (1927). Coordination of the respiration and circulation with variations in bodily activity. Lancet, 213:213-218.

Droghetti,P.; Borsetto,C.; Casoni,I.; Cellini,M.; Ferrari,M.; Paolini,A.R.; Ziglio,P.G.; Conconi,F. (1985). Noninvasive determinations of the anaerobic threshold in canoeing, cross-country skiing, cycling, roller and iceskating, rowing, and walking. European Journal of Apllied Physiology, 53:299-303.

Durnin,J.V.G.A. (1960). Effects of short period training of varying severity in some measurements of physical fitness. Journal of Applied Physiology, 15:161-165.

Durnin,J.V.G.A. and Womersley,J. (1974). Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. British Journal of Nutrition, 32:77-92.

Dwyer,J. and Bybee,R. (1983). Heart rate indices of the anaerobic threshold. Medicine and Science in Sports and Exercise, 15(1):72-76.

Eddy,D.P.; Sparks,K.L.; Adelizi,D.A. (1977). The effects of continuous and interval training in women and men. European Journal of Applied Physiology, 37:83-92.

Ekblom,B.; Astrand,P.O.; Saltin,B.; Stenberg,J.; Wallstrom,B. (1968). Effect of training on circulatory response to exercise. Journal of Applied Physiology, 24:518-528.

Ellefson,R.D. and Caraway,W.T. (1982). Lipids and proteins. In: Tietz,N.W. (Ed.), Fundamentals of Clinical Chemistry.

Philadelphia: W.B. Saunders, pp.474-541.

Ericksson,B.; Gollnick,P. and Saltin,B. (1972). Muscle metabolism and enzyme activities after training in boys 11-13 years old. Acta Physiologica Scandinavica, 87:231-239.

Essen,B. (1977). Intramuscular substrate utilization during prolonged exercise. In: P. Milvy (ed.), The Marathon: Physiological, Medical, Epidemological and Psychological Studies. Annals of the New York Academy of Sciences,301:225-231.

Essen,B.; Hagenfeldt,L.; Kaijser,L. (1977). Utilization of blood-borne and intramuscular substrates during continuous and intermittent exercise in man, Journal of Physiology (London), 265:489-506.

Fahey,T.D. and Brown,C.H. (1973). The effects of anabolic steroid on the strength, body composition, and endurance of college males when accompanied by a weight training program. Medicine and Science in Sports, 5:272-296.

Fairshter,R.D.; Walters,J.; Salness,K.; Fox,M.; Minh,V.; Wilson,A.F. (1983). A comparison of incremental exercise tests during cycle and treadmill ergometry. Medicine and Science in Sports and Exercise, 15(6):549-554.

Farrell,P.A.; Wilmore,J.H.; Coyle,E.F.; Billings,J.E. (1979). Plasma lactate accumulationand distance running performance. Medicine and Science in Sports, 11:338-344.

Forbes,G.B. (1976). The adult decline in lean body mass. Human Biology, 48(1):161-173.

Forbes,G.B. and Reina,J.C. (1970). Adult lean body mass declines with age:some longitudinal observations. Metabolism, 19:653-663.

Foster,V.L.; Hume,G.J.E.; Dickinson,A.L.; Chatfield,S.J.; Byrnes,W.C. (1986). The reproducibility of VO2 max, ventilatory, and lactate thresholds in elderly women. Medicine and Science in Sports and Exercise, 18(4):425-430.

Forsythe,M.L. and Sinning,W.E. (1973). The anthropometric estimation of body density and lean body weight of male athletes. Medicine and Science in Sports,5:174-180.

Fortney,S.M.; Nadel,E.R.; Wenger,C.B.; Bove,J.R. (1982). Effect of blood volume in sweating rate and body fluids in exercising humans. Journal of Applied Physiology, 51:1594-1600.

Fox,E.L.; Bartels,R.L.; Klinzing,J. and Ragg,K. (1977). Metabolic responses to interval training programs of high and low power output. Medicine and Science in Sports, 9(3)191-196.

Fox,E.L.; Bartels,R.L.; Billings,C.E.; O'Brien,R.; Bason,R. and Mathews,D.K. (1975). Frequency and duration of interval training programs and changes in aerobic power. Journal of Applied Physiology, 38:481-484.

Fox,E.L.; Bartels,R.L.; Billings,C.E.; Mathews,D.K.; Bason,R. and Webb,W.M. (1974). Intensity and distance of interval training programs and changes in aerobic power. Medicine and Science in Sports, 5(1):18-22.

Fox,E.L.; Robinson,S.; Wiegman,D.L. (1969). Metabolic energy sources during continuous and interval training. Journal of Applied Physiology, 27:174-178.

Fredholm,B.B. (1971). The effect of lactate in canine subcutaneous adipose tissue in situ. Acta Physiologica Scandinavica, 81:110-123.

Friedberg,S.J.; Harlan,W.R.Jr.; Trout,D.L.; Estes,E.H.Jr. (1960). The effect of exercise on the concentration and turnover of plasma nonesterified fatty acids. Journal of Clinical Investigation, 39:215-220.

Friedberg,S.J. and Estes,E.H.Jr. (1962). Direct evidence for the oxidation of free fatty acids by peripheral tissues. Journal of Clinical Investigation, 41:677-681.

Fritz,T.B.; Davis,D.G.; Holtrop,R.H.; Dundee,H. (1958). Fatty acid oxidation by skeletal muscle during rest and activity. American Journal of Physiology, 194:379-386.

Gaesser,G.A.; Poole,D.C.; Gardner,B.P. (1984). Dissociation between VO2 max and ventilatory threshold responses to endurance training. European Journal of Applied Physiology 53:242-247.

Garfield,D.S.; Ward,P.; Cobb,R.; Disch,J.; Southwick,D. (1979). Circuit Weight Training. Houston: Dynamics Health Equipment.

Gautier,H.; Maillard,).; Vincent,J.; Caoni,D. (1978). Gas exchange during exercise in normoxia and hyperoxia. Respiratory Physiology, 33:199-211.

Getchell,L.H. and Moore,J.C. (1975). Physical training comparative responses of middle-aged adults. Archives of Physical Medicine and Rehabilitation, 56:250-254.

Gettman,L.R.; Ayrtes,J.J.; Pollock,M.L.; Durstine,J.L.; Grethman,W. (1978). The effect of circuit weight training on strength, cardiorespiratory function, and body composition of adult men. Medicine and Science in Sports, 10:171-176.

Gettman,L.R.; Ayrtes,J.J.; Pollock,M.L.; Durstine,J.L.; Grethman,W. (1979). Physiological effects on adult men of circuit strength training and jogging. Archives of Physical Medicine and Rehabilitation, 60:115-120.

Gibbons,E.; Jessup,G.T.; Wells,T.D.; Werthmann,D.A. (1983). Effects of various training intensity levels on anaerobic threshold and aerobic capacity in females. Journal of Sports Medicine, 23:315-318.

Girandola,R.N. (1976). Body composition changes in women: effects of high and low exercise intensity. Archives of Physical Medicine and Rehabilitation, 57:297-300.

Girandola,R.N. and Katch,V. (1973). Effects of nine weeks of physical training on aerobic capacity and body composition in college men. Archives of Physical Medicine and Rehabilitation, 54:521-524.

Gladden,L.B.; Yates,J.W.; Stremel,R.W.; Stamford,B.A. (1985). Gas exchange and lactate thresholds: inter- and intraevaluator agreement. Journal of Applied Physiology, 58(6):2082-2089.

Glick,Z. and Kaufman,N. (1976). Weight and skinfold thickness changes during a physical training course. Medicine and Science in Sports, 8(2):109-112.

Gold,D. (1958). Comment on "A critique of tests of significance". American Sociological Review, 24:85-86.

Golden,H.P. and Vaccaro,P. (1984). The effects of endurance training intensity on anaerobic threshold. Journal of Sports Medicine, 24:205-211.

Goldrick,R.B. and McLoughlin,G.M. (1970). Lipolysis and lipogenesis from glucose in human fat cells of different sizes. Effects of insulin, epinephrine, and theophyline. Journal of Clinical Investigation, 49:1213-1223.

Goodhart,R.S. and Shils,M.E. (1980). Modern Nutrition in Health and Disease. Lea & Febiger, 6th Edition.

Gordon,R.S.Jr. (1957). Unesterified fatty acid in human blood plasma. II. The transport function of unesterified fatty acid. Journal of Clinical Investigation, 36:810-815.

Green,H.J. and Hughson,R.L. (1985). Letter to the editor-in-chief. Medicine and Science in Sports and Exercise, 17(5):621-622.

Green,H.J.; Hughson,R.L.; Orr,G.W.; Ranney,D.A. (1983). Anaerobic threshold, blood lactate, and muscle metabolites in progressive exercise. Journal of Applied Physiology, 50(4):1032-1038.

Gregory,L.W. (1979). The development of aerobic capacity: a comparison of continuous and interval training. Research Quarterly, 50:199-206.

Hagberg,J.M.; Coyle,E.F.; Carroll,J.E.; Miller,J.M.; Martin,W.H.; Brooke,M.H. (1982). Exercise hyperventilation in patients with McArdle's disease. Journal of Applied Physiology, 52:991-994.

Hamosh,M.; Hamosh,P.; Bar-Moar,J.A.; Cohen,H. (1963). Fatty-acid metabolism by human adipose tissues. Journal of Clinical Investigation, 42:1648-1652.

Harrison,T.R. and Pilcher,C. (1930). Studies in congestive heart failure. The respiratory exchange during and after exercise. Journal of Clinical Investigation, 8:291-315.

Havel,R.J.; Pernow,B.; Jones,N.L. (1967). Uptake and release of free fatty acids and other metabolites in the legs of exercising men. Journal of Applied Physiology, 23:90-96.

Havel,R.J. (1971). Influence of intensity and duration on supply and use of fuels. In: Pernow,P. and Saltin,B. (eds.), Muscle Metabolism During Exercise. New York: Plenum Press, p.315.

Heigenhauser,G.J.F.; Sutton,J.R.; Jones,N.L. (1983). Effect of glycogen depletion on the ventilatory response to exercise. Journal of Applied Physiology, 54:470-474.

Henricksson,J. and Retman,J, (1977). Time course of changes in human skeletal muscle succinate dehydrogenase and cytochrome oxidase activities and maximal oxygen upatke with physical activity and inactivity. Acta Physiologica Scandinavica, 99:91-97.

Hickson,R.C.; Hagberg,J.M.; Ehsani,A.A. and Holloszy,J.O. (1981). Time course of the adaptative responses of aerobicpower and heart rate of training. Medicina and Science in Sports, 13(1):17-20.

Hill,D.W.; Cureton,K.J.; Grisham,S.C. and Collins,M.A. (1987). Effect of training on the rating of perceived exertion at the ventilatory threshold. European Journal of Applied Physiology, 56:206-211.

Hill, A.V.; Long,C.N.; Lupton,H. (1924). Muscular exercise, lactic acid, and the supply and utilization of oxygen. Part VI - The oxygen debt at the end of exercise. Proceedings of Royal Society (London), Ser. B 97:127-137.

Hirsch,J. and Han,P.W. (1969). Cellularity of rat adipose tissue: effects of growth, starvation and obesity. Journal of Lipid Research, 10:77-82.

Hirsch,J. and Knittle,J.C. (1970). Cellularity on obese and non-obese human adipose tissue. Federation Proceedings, 29:1516-1521.

Hirsch,J.; Knittle,J.C.; Salans,L.B. (1966). Cell lipid content and cell number in obese and non-obese human adipose tissue. Journal of Clinical Investigation, 45:1023.

Hirsch,L. (1977). Trainingsformen zur verbesserung der aeroben kapazitat. Leistungssport (Beiheft), 7:93-103.

Hogan,A.C. and Welch,H.G. (1986). Effect of altered arterial O_2 tensions on muscle metabolism in dog skeletal muscle during fatiguing work. American Journal of Physiology, 251 (Cell Physiology 20):C216-C222.

Hollemberg,C.H.; Vost,A.; Patton,R.C. (1970). Regulation of adipose mass: control of fat cell development and lipid content. Recent Progress in Hormonal Research, 26:463-495.

Hollman,W. (1959). The relationship between pH, lactic acid, potassium in the arterial and venous blood, the ventilation (PoW) and pulse frequency during increasing spiroergometric work in endurance- trained and untrained persons. Proceedings of the Pan-American Congress of Sports Medicine. Chicago.

Hollman,W. (1961). Zur Frage der Dauerleistungsfahigkeit. Fortschr Med, 79:439.

Hollman,W. (1963). Hochst- und Daverleistungsfahigkeit des Sportlers. Munchen: Barth.

Holloszy,J. (1975). Adaptation of skeletal muscle to endurance exercise. Medicine and Science in Sports, 7:155-164.

Hoppeler,H.; Luthi,P.; Claassen,H.; Weibel,E.R. and Howald,H. (1973). The ultra-structure of the normal human muscle. A morphometric analysis of untrained men, women and well-trained orienteers. Pfluger Archives, 244:217-232.

Houghton,C.R.S.; Hawkins,R.; Williamson,D.; Krebs,H.A. (1971). An explanation for the lowering of blood ketone-body concentration in starved rats during short-term exercise. Biochemistry Journal, 124:56 (Abstract).

Houston,M.; Bentzen,H.; Larsen,H. (1979). Interrelationships between skeletal muscle adaptations and performance as studied by detraining and retraining. Acta Physiologica Scandinavica, 105:163-170.

Hubbard,R.W. and Mathew,W.T. (1971). Growth and lipolysis of rat adipose tissue: effect of age, body weight, and food intake. Journal of Lipid Research, 12:286-293.

Hughes,R.L.; Clode,M.; Edwards,R.H.T.; Goodwin,T.J.; Jones,N.C. (1968). Effect of inspired O_2 on cardiopulmonary and metabolic responses to exercise in man. Journal of Applied Physiology, 24:336-347.

Hughes,E.F.; Turnner,S.C.; Brooks,G.A. (1982). Effects of glycogen depletion and pedaling speed on 'anaerobic threshold'.Journal of Applied Physiology, 52(6):1598-1607.

Hughson,R.L. and Green,H.J. (1982). Blood acid-base and lactate relationships studied by ramp test. Medicine and Science in Sports and Exercise, 14:297-302.

Idstrom,J.P.; Harihara Subamaniam,V.; Chance,B.; Schersten,T.; Bylund-Felenius,A.C. (1985). Oxygen dependence of energy metabolism in contracting and recovering rat skeletal muscle. American Journal of Physiology, 248 (17):H40-H48.

Issekutz,B.Jr. and Miller,H. (1962). Plasma free fatty acids during exercise and the effect of lactic acid. Proceedings of the Society for Experimental Biology and Medicine, 110:237-239.

Issekutz,B.Jr.; Miller,H.I.; Paul,P.; Rodahl,K. (1965a). Aerobic work capacity and plasma FFA and glycerol turnover. Journal of Applied Physiology, 20:293-296.

Issekutz,B.Jr.; Miller,H.I.; Paul,P.; Rodahl,K. (1965b) Effect of lactic acid on free fatty acids and glucose oxidation in dogs. American Journal of Physiology, 209:1137-1144.

Issekutz,B.Jr. and Rodahl,K. (1961). Respiratory quotient during exercise. Journal of Applied Physiology, 16:606.

Issekutz,B.Jr.; Shaw,W.A.; Issekutz,T.B. (1975). Effect of lactate on FFA and glycerol turnover. Journal of Applied Physiology, 39(3):349-353.

Ivy,J.L.; Costill,D.L.; Van Handel,P.J.; Essig,D.A.; Lower,R.W. (1981). Alterations in the lactate threshold with changes in substrate availability. International Journal of Sports Medicine, 2(3):139-142.

Ivy,J.L.; Whiters,R.T.; Van Handel,P.J.; Elger,D.H.; Costill,D. (1980). Muscle respiratory capacity and fibre type as determinants of the lactate threshold. Journal of Applied Physiology, 48(3):523-527.

Jackson,J.H. (1968). Cardiorespiratory adaptations to training at specified frequencies. Research Quarterly, 39:295-300.

Jackson,A.S. and Pollock,M.L. (1978). Generalized equations for predicting body density of men. British Journal of Nutrition, 40:497-504.

Jackson,A.S.; Pollock,M.L.; Ward,A. (1980). Generalized equations for predicting body density in women. Medicine and Science in Sports and Exercise, 12:175-182.

Jackson,A.S. and Pollock,M.L. (1982). Steps toward the development of generalized equations for predicting body composition of adults. Canadian Journal of Applied Sport Sciences, 7(3):189-196.

Jirka,Z. and Adamus,M. (1965). Changes in ventilation equivalents in young people inthe course of three years of training. Journal of Sports Medicine, 5:1-6.

Jobsis,F.F. and Stainsby,W.N. (1968). Oxidation of NADH during contractions of circulated mammalian skeletal muscle. Respiratory Physiology, 4:292-300.

Johnson,R.E.; Mastropaolo,J.A.; Wharton,M.A. (1972). Exercise, dietary intake, and body composition. Journal of the American Dietetic Association,61:399-403.

Johnson,P.R.; Zucker,L.M.; Cruce,J.A.F.; Hirsch,J. (1971). Cellularity of adipose depots in the genetically obese Zucker rat. Journal of Lipid Research, 12:706-714.

Jones,N.L. (1984). Evaluation of a microprocessor-controlled exercise testing syste. Journal of Applied Physiology, 57(5):1312-1318.

Jorfeldt,L. (1970). Metabolism of L(+) lactate in human skeletal muscle during exercise. Acta Physiologica Scandinavica Suppl., 338.

Jorfeldt,L.; Juhein-Dannfeldt,A.; Karlsson,J. (1978). Lactate release in relation to tissue lactate in human skeletal muscle during exercise. Journal of Applied Physiology, 44:350-352.

Katch,F.I. and McArdle.W.D. (1973). Prediction of body density from simple anthropometric measurements in college age women and men. Human Biology, 45:445-454.

Katch,F.I.; Michael,E.D.; Jones,E.M. (1969). Effects of physical training on the body composition and diet of females. Research Quarterly, 40:99-104.

Karlsson,J. and Jacobs,I. (1982). Onset of blood latate accumulation during muscular exercise as a theoretical concept. I. Theoretical considerations. International Journal of Sports Medicne, 3:190-201.

Katz,A. and Sahlin,K. (1987). Effect of decreased oxygen availability on NADH and lactate contents in human skeltal muscle during exercise. Acta Physiologica Scandinavica, 131:119-128.

Keppel,G. (1973). Design and Analysis: A Researcher Handbook. Prentice-Hall Inc., Englewood Cliffs, New Jersey.

Kerlinger,F.N. (1973). Foundations of Behavioral Research. Holt, Rinehart and Winston, 2nd Edition.

Kiens,B.; Jorgensen,I.; Lewis,S.; Jensen,G. andLithell,J. (1980). Increased plasma HDL-cholesterol and apo A-1 in sedentary middle-aged men after physical conditioning. European Journal of Clinical Investigation, 10:203-209.

Kissebah,A.H.; Vydelingum,N.1 Murray,R.; Evans,E.J.; Hartz,A.J.; Kalkhoff,R.K.; Adams,P.W. (1982). Relation of body fat distribution to metabolic complications to obesity. Journal of Clinical Endocrinology and Metabolism, 54:254-260.

Kilbom,A.; Hartley,L.H.; Saltin,B.; Bjure,J.; Grimby,G.; Astrand,I. (1969). Physical training in sedentary middle-aged and older men. Scandinavian Journal of Clinical Laboratory Investigation, 24:315-322.

Kilbom,A. (1971). Physical training in women. II. The influence of training results by sex and age of subjects by their initial maximal aerobic power and by training intensity. Scandinavian Journal of Clinical Invastigation, Supplementun, 119:13-18.

Kindermann,W.G.; Simon,G.; Keul,J. (1979). The significance of the aerobic-anaerobic transition for the determination of workload intensities during endurance training. European Journal of Applied Physiology, 42(1):25-34.

Kirkland,S. and Gurr,M.I. (1979). Adipose tissue cellularity: a review. 2. The relationship between cellularity and obesity. *International Journal of Obesity*, 3:15-55.

Knuttgen,H.G.; Nordesjo,L.O.; Ollander,B. and Saltin,B. (1973). Physical conditioning through interval training with young male adults. *Medicine and Science in Sports*, 5(4):220-226.

Kollias,J.; Boileau,R.A.; Barlett,H.L.; Buskirk,E.R. (1972). Pulmonary function and physical conditioning in lean and obese subjects. *Archive of Environmental Health*, 25:146-150.

Kral,J.G.; Bjorntorp,P.; Schersten,T.; Sjostrom,L. (1977). Body composition and adipose tissue cellularity before and after jejuno-ileostomy in severely obese subjects. *European Journal of Clinical Investigation*, 7:413-419.

Krotkiewsky,M. and Bjorntorp,P. (1976). The effect of progesterone and of insulin administration in regional adipose tissue cellularity in the rat. *Acta Physiologica Scandinavica*, 96:122-126.

Krotkiewsky,M. and Bjorntorp,P. (1978). The effects of estrogen treatment of carcinoma of the prostate on regional adipocyte size. *Journal of Endocrinology Investigation*, 1:365-368.

Krotkiewsky,M.; Blohme,B.; Lindholm,N.; Bjorntorp,P. (1976). The effects of adrenal corticosteroids on regional adipocyte size in man. *Journal of Clinical Endocrinology and Metabolism*, 42:91-97.

Krotkiewsky,M.; Sjostrom,L.; Bjorntorp,P.; Smith,U. (1975). Regional adipose tissue cellularity in relation to metabolism in young and middle-aged women. *Metabolism*, 24:703-710.

Krotkiewsky,M.; Bjorntorp,P.; Sjostrom,L.; Smith,U.; (1983). Impact of obesity on metabolism in men and women. Importance of regional adipose tissue distrbution. *Journal of Clinical Investigation*, 72(3):1150-1162.

Kumagai,S.; Tanaka,K.; Matsuura,Y.; Matsuzaka,A.; Hirakoba,K.; Asano,K. (1982). Relationships of the anaerobic threshold with the 5 km, 10 km, and 10 km mile races. *European Journal of Applied Physiology*, 49:13-23.

Leon,A.S.; Conrad,J.; Hunninghake,D.B.; Serfass,R. (1979). Effects of vigorous walking program on body composition, and carbohydrate and lipid metabolism in obese young men. *American Journal of Clinical Nutrition*,33:1776-1787.

Linnarson,D.; Karlsson,J.; Fagraeus,L.; Saltin,B. (1974). Muscle metabolites and oxygen deficit with exercise and hypoxia and hyperoxia. Journal of Applied Physiology, 36:399-402.

Lipson,L.C.; Bonow,R.O.; Schaefer,E.J.; Brewer,H.B.; Lindgren,F.T. (1980). Effect of exercise conditioning on plasma high density lipoproteins and other lipoporoteins. Atherosclerosis, 37:529-538.

Lohman,T.G. (1981). Skinfolds and body density and their relation to body fatness: a review. Human Biology, 53:181-225.

Lundin,G. and Strom,G. (1947). The concentration of blood lactic acid in man during muscular work in relation to the partial pressure of oxygen of the inspired air. Acta Physiologica Scandinavica, 13:253-266.

MacDougall,J.D. (1977). The anaerobic threshold: its significance for the endurance athlete. Canadian Journal of Applied Sport Sciences, 2:137-140.

MacDougall,J.D. and Sale,D. (1981). Continuous vs interval training: a review for the athlete and the coach. Canadian Journal of Applied Sport Sciences, 6:93-97.

Mader,A.; Liesen,H.; Heck,H.; Philippi,H.; Rost,R.; Schuerch,P.; Hollman,W. (1976a). Zur Beurteilung der sportartspezifischen Audaurerleistungsfaehigkeit im Labor. Sportarxt Sportmedizin, 4:80-88.

Mader,A.; Liesen,H.; Heck,H.; Philippi,H.; Rost,R.; Schuerch,P.; Hollman,W. (1976b). Zur Beurteilung der sportartspezifischen Audaurerleistungsfaehigkeit im Labor. Sportarzt Spotmedizin, 5:109-112.

Martin,A.D.; Drinkwater,D.T.; Clarys,J.P.; Ross,W.D. (1981). Estimation of body fat: a new look at some old assumptions. Physician and Sportsmedicine, 9(7):21-22.

Matsumura,N.; Nishijima,H; Kojima,S; Hashimoto,F; Minami,M. and Yasuda,H. (1983). Circulation, 68(360-367.

McGowan,C.R.; Epstein,L.H.; Kupfer,D.J.; Bulick,C.M. and Robertson,R.J. (1986). The effect of exercise on non-restricted caloric intake in male joggers. Appetite, 7:97-105.

McLellan,T.M. (1985). Ventilatory and plasma lactate response with different exercise protocols: a comparison of methods. International Journal of Sports Medicine, 6(1):30-35.

McLellan,T.; Feroah,T.; Skinner,J.S. (1981). The effect of workload duration on the determination of the aerobic and anaerobic thresholds. Medicine and Science in Sports, 12:86 (Abstract).

Mennely,G.R. and Kaltreider,N.L. (1949). Volume of lung determined by helium dilution. Journal of Clinical Investigation, 28:129-139.

Mickelson,T.C. and Hagerman,F.C. (1982). Anaerobic threshold measurements of elite oarsmen. Medicine and Science in Sports and Exercise, 14(6):440-444.

Milic-Emili,G.; Petit,J.M. and Deroanne,R. (1962). Mechanical work of breathing during exercise in trained and untrained subjects. Journal of Applied Physiology, 17:43-46.

Miller,H.; Issekutz,B.Jr.; Rodahl,K. (1963). Effect of exercise on the metabolism of fatty acids in the dog. American Journal of Physiology, 205:167.

Misner,J.S.; Boileau,R.A.; Massey,B.H.; Mayhew,J.L. (1974). Alterations in the body composition of adult men during selected physical training programs. Journal of American Geriatric Society, 22:33-38.

Mole,P.A.; Oscai,L.B.; Holloszy,J.O. (1971). Adaptation of muscle to exercise: increase in levels of palmityl CoA synthetase, carnitine palmytyltransferase, and palmityl CoA dehydrogenase, and in the capacity to oxidize fatty acids. Jounal of Clinical Investigation, 50:2323-2330.

Montoye,H.J.; Block,W.D.; Metzner,H.L. and Keller,J.B. (1976). Habitual physical activity and serum lipids: males aged 16-64 in a total comunity. Journal of Chronic Disease, 29:697-709.

Moody,D.L.; Kollias,J.; Buskirk,E.R. (1969). The effect of a moderate exercise program on body weight and skinfold thickness in overweight college women. Medicine and Sciences in Sports, 1:75-80.

Moritani,T. and de Vries,H.A. (1980). Anaerobic threshold determination by surface electromyography. Medicine and Science in Sports and Exercise, 12:86 (Abstract).

Morrison,D.E. and Ramon,H. (1969). Significance tests reconsidered. American Sociologist, 4:131-140.

Naimark,A.; Wasserman,K.; McIlroy,M.B. (1964). Continuous measurement of ventilatory exchange ratio during exercise: a test of cardiovascular function. Journal of Applied Physiology, 19:644.

Neary,P.J.; MacDougall,J.D.; Bachus,R.; Wenger,H.A. (1985). The relationship between lactate and ventilatory thresholds: coincidental or cause and effect ? European Journal of Applied Physiology, 54:104-108.

Neary,P.J. and Wenger,H.A. (1985a). The effects of one- and two-legged exercise on the lactate and ventilatory threshold. European Journal of Applied Physiology, 54:591-595.

Neary,P.J. and Wenger,H.A. (1985b). The effects of continuous versus discontinuous cycling on the lactate and ventilation thresholds. Journal of Human Movement Studies, 11:151-157.

Neary,P.J. and Wenger,H.A. (1985c). The effects of prior exercise on the lactate and ventilatory thresholds. Journal of Sport Sciences, 3:189-196.

Neil,W.A.; Jensen,P.E.; Rich,G.B.; Nerschkul,J.D. (1969). Effect of decreased O_2 supply to tissue on the lactate /pyruvate ratio in blood. Journal of Clinical Investigation, 48:1862-1869.

Nemoto,I. and Miyashita,M. (1981). Aerobic and anaerobic threshold of Japanese male adults. Journal of Human Ergology, 9:183-189.

Nikolic,Z. and Todorovic,B. (1984). Anaerobic threshold during arm and leg exercises and cardiorespiratory fitness tests in a group of male and female students International Journal Sports Medicine, 5(6):330-335.

Norris,A.H.; Lundy,T.; Shock,N.W. (1963). Trends in selected indices of body composition in men between 30 and 80 years. Annals of the New York Academy of Sciences, 110:623-639.

Norton,A.C. (1982). Development and testing of a microprocessor-controlled system for measurement of gas exchange and related variables in man during rest and exercise. Beckman Instruments - Reprint 025, Anaheim, CA.

Novak,L.P. (1972). Aging, total body potassium, fat-free mass and cell mass in males and females between ages 18 and 85 years. Journal of Gerontology, 27:438-443.

Nupp,W.F. (1970). The relative effectiveness of four cardiorespiratory conditioning programs. Journal of Sports Medicine, 10:84-89.

Orr,G.W.; Green,H.J.; Hughson,R.L.; Bennett,G.W. (1982). A computer linear regression model to determine ventilatory anaerobic threshold. Journal of Applied Physiology, 52(5):1349-1352.

Oscai,L.B. and Williams,B.T. (1968). Effect of exercise on overweight middle-aged males. Journal of the American Geriatry Society, 16:794-797.

Oscai,L.B.; Williams,B.T.; Hertig,B. (1968). Effects oexercise on blood volume. Journal of Applied Physiology, 24:622-624.

Owles,W.H. (1930). Alterations in the lactic acid content of the blood as a result of light exercise and associated changes in the CO2 combining power of the blood and in the alveolar CO2 pressure. Journal of Physiology (London), 69:214-237.

Palmer,W.K. and Tipton,C.M. (1973). Influence of hypophysectomy and training on size of isolated fat cells. American Journal of Physiology, 224:1206-1209.

Parizkova,J. (1974). Body composition and exercise during growth and development. In: Physical Activity: Human Growth and Development, G.L. Rarick (Ed.). New York: Academic Press.

Parizkova,J. and Poupa,O. (1963). Some metabolic consequences of adaptation to muscular work. British Journal of Nutrition, 17:341-345.

Parmeggiani,A. and Bowman,R. (1963). Regulation of phosphofructokinase activity by citrate in normal and diabetic muscle. Biophysics Research Community, 12:268-273.

Passmore,R.; Strong,J.A.; Ritchie,F.J. (1958). The chemical composition of the tissue lost by obese patient on a reducing regimen. British Journal of Nutrition, 12:113-122.

Pattengale,P. and Holloszy,J. (1967). Augmentation of skeletal muscle myoglobin by a program of treadmill running. American Journal of Physiology, 213:783-787.

Pendergast,D.; Cerretelli,P.; Rennie,D.W. (1979). Aerobic and glycolytic metabolism in arm exercis[illegible] Journal of Applied Physiology, 47:754-760.

Perret,T.C. (1960). Hyperoxie et regulation de la ventilation durant l'exercise musculaire. Helvetica Physiologica Acta, 18:72-97.

Pessenhofer,H.; Schwaberger,G.; Schmid,P. (1981). Zur Bestimmung des individuellen aerob-anaeroben Uebergangs. Disch. Z. fuer Sportmedizin, 4:15-17.

Pollock,M.L. (1973). The quantification of endurance training programs. In: Exercise and Sport Science Reviews, J.H. Wilmore (Ed.). New York: Academic Press, Vol. 1:155-188.

Pollock,M.L.; Broida,J.; Kendrick,Z.; Miller,H.S.; Janeway,R.; Linnerud,A.C. (1972). Effects of training two days per week at different intensities on middle-aged men. Medicine and Science in Sports, 4:192-197.

Pollock,M.L.; Cureton,T.K.; Greninger,L. (1969). Effects of frequency of training on working capacity, cardiovascular function, and body composition of adult men. Medicine and Science in Sports, 1:70-74.

Pollock,M.L.; Dawson,G.A.; Miller,H.S.Jr. (1976). Physiologic responses of men 49 to 65 years of age to endurance training. Journal of the American Geriatry Society, 24:97-104.

Pollock,M.L.; Dimmick,J.; Miller,H.S.; Kendrik,Z. and Linnerud,A.C. (1975). Effects of mode of training on cardiovascular function and body composition of adult men. Medicina and Science in Sports, 7(2):139-145.

Pollock,M.L. and Jackson,A.S. (1984). Research progress in validation of clinical methods of assessing body composition. Medicine and Science in Sports, 16(6):606-613.

Pollock,M.L.; Miller Jr.,H.S.; Janeway,R.; Linnerud,A.C.; Robertson,B.; Valentino,R. (1971). Effects of walking on body composition and cardiovascular function of middle-aged men. Journal of Applied Physiology, 30:126-130.

Pollock,M.L.; Miller,H.S.Jr.; Kendrick,Z.; Linnerud,A.C. (1975). Effects of mode of training on the cardiovascular functions and body composition of adult men. Medicine and Science in Sports, 7:139-145.

Pollock,M.L.; Schmidt,D.H. and Jackson,A.S. (1980). Measurement of cardiorespiratory fitness and body composition in the clinical setting. Comparative Therapy, 6:12-27.

Pollock,M.L.; Tiffany,J.; Gettman,L.; Janeway,R.; Lofland,H. (1969). Effects of frequency of training on serum lipids, cardiovascular function, and body composition. In: Exercise and Fitness, B.D. Franks (Ed.). Chicago: Athletic Institute, pp.161-178.

Poole,D.C. and Gaesser,G.A. (1985). Response of ventilatory and lactate thresholds to continuous and interval training. Journal of Applied Physiology, 58(4):1115-1121.

Powers,S.K.; Dodd,S.; Deadson,R.; Byrd,R.; McKnight,T. (1983). Ventilatory threshold, running economy, and distance running performance of trained athletes. Research Quarterly for Exercise and Sport, 54:179-182.

Powers,S.K.; Dodd,S.; Garner,R. (1984). Precision of ventilatory and gas exchange alterations as a predictor of the anaerobic threshold. European Journal of Applied Physiology, 52:173-177.

Prud'homme,D.; Bouchard,C.; Leblanc,C.; Landry,F.; Lortie,G.; Boulay,M.R. (1984). Reliability assessment of ventilatory thresholds. Journal of Sports Sciences, 2:13-24.

Pruett,E.D.R. (1970). FFA mobilization during and after prolonged severe muscular work in men. Journal of Applied Physilogy, 29:809-815.

Rahn,H. (1966). Introduction to the study of man at high altitudes: conductance of O_2 from the environment to the tissues. In: Life at High Altitudes, Pan American Health Organization, W.H.O., Washington, D.C.

Ready,A.E. and Quinney,H.A. (1982). Alterations in anaerobic threshold as the result of endurance training and detraining. Medicine and Science in Sports and Exercise, 14(4):292-296.

Reggiani,E.; Bertoloni,S.; Chiodini,G. Elicio,N. and Montanari,D. (1984). Effects of physical activity and diet on lipemic risk factors for artherosclerosis in women. International Journal of Sports Medicine, 5:183-186.

Reinhard,U.; Muller,P.H.; Schmulling,R.M. (1979). Determination of anaerobic threshold by the ventilation equivalent in normal individuals. Respiration, 38:36-42.

Reybrouck,T.; Chesquiere,J.; Weymanas,M.; Amery,A. (1986). Ventilatory threshold measurement to evaluate maximal endurance performance. International Journal of Sports Medicine, 7:26-29.

Reybrouck,T.; Weymans,M.; Stijns,H.; Knops,J.; Van der Hauwaert,L. (1985). Ventilatory anaerobic threshold in healthy children. European Journal of Applied Physiology, 54:278-284.

Rhodes,E.C. and McKenzie,D.C. (1984). Predicting marathon time from anaerobic threshold measurements. The Physician and Sports Medicine, 12(1):95-98.

Ribeiro,J.P.; Hughes,V.; Fielding,R.A.; Holden,W.; Evans,W. and Knuttgen,H.G. (1986). Metabolic and ventilatory responses to steady state exercise relative to lactate thresholds. European Journal of Applied Physiology, 55:215-221.

Ribisl,P.M. (1969). Effects of training upon the maximal oxygen uptake of middle-aged men. International Z. Angew Physiology, 27:151-160.

Ritthaler,F.; Weiss,M.; Hack,F.; Weicker,H. (1980). Two biopsy techniques for human subcutaneous adipose tissue. International Journal Sports Medicine, 1:50-51.

Rivera,M.A.; Metz,K.F.; Robertson,R. (1980). Metabolic and performance responses to anaerobic threshold and high intensity training. Medicine and Science in Sports and Exercise, 12(2):125 (Abstract)

Robinson,T. and Suec,A.A. (1980). The relationship of training intensity and anaerobic threshold to endurance performance. Medicine and Science in Sports and Exercise, 12(2):124 (Abstract).

Rognum,T.O.; Rodahl,K.; Opstad,P.K. (1982). Regional differences in the lipolytic response of the subcutaneous fat depots to prolonged exercise and severe energy deficiency. European Journal of Applied Physiology, 49:401-408.

Roskamm,H. (1967). Optimum patterns of exercise for healthy adults. Canadian Medical Association Journal, 96:895-898.

Ross,W.D.; Hebbelinck,M.; Brown,S.R.; Faulkner,R.A. (1978). Kinanthropometric landmarks and terminology. In: R.J. Shepard and H. Lavallee (Eds.). Charles C. Thomas, Springfield, Illinois, 44-50.

Ross,W.D. and Marfell-Jones,M.J. (1982). Kinanthropometry. In: Physiological Testing of the Elite Athlete, J.D. MacDougall; H.A. Wenger and H.J. Green (Eds.). Canadian Association of Sport Sciences and Sport Medicine Council of Canada, p.75-115.

Rotstein,A.; Dotan,R.; Bar-Or,O. and Tenenbaum,G. (1986). Effect of training on anaerobic threshold, maximal aerobic power and anaerobic performance of preadolescent boys. International Journal of Sports Medicine, 7:281-286.

Rowell,L.B. (1974). Human cardiovascular adjustments to exercise and thermal stress. Physiological Reviews, 54:75-159.

Rowell,L.B.; Blackmon,J.R.; Kenny,M.A. and Escourrou,P. (1984). Splanchnic vasomotor and metabolic adjustments to hypoxia and exercise in humans. American Journal Physiology, 247(Heart Circulation Physiology 16):H251-H258.

Rusko,H.; Rahkila,P.; Karvinen,E. (1980). Anaerobic threshold, skeletal muscle enzymes and fiber composition in young female cross-country skiers. Acta Physiologica Scandinavica, 108:263-268.

Rusko,H.; Luhtanen,P.; Rahkila,P.; Vitasalo,J.; Rehunen,S.; Harkonen,M. (1986). Muscle metabolism, blood lactate and oxygen uptake in steady state exercise at aerobic and anaerobic thresholds. European Journal of Applied Physiology, 55:181-186.

Sady,S.; Katch,V.; Freedson,P.; Weltman,A. (1980). Changes in metabolic acidosis: evidence for an intensity threshold. Journal of Sports Medicine and Physical Fitness, 20:41-46.

Salans,L.B.; Cushman,S.W.; Weismann,R.E. (1973). Studies of human adipose tissue: adipose cell size and number in non-obese and obese patients. Journal of Clinical Investigation, 52:929-941.

Saltin,B.; Blomqvist,G.; Mitchell,J.H.; Johnson Jr.,R.L.; Wildenthal,K. and Chapman,C.B. (1968). Response to submaximal and maximal exercise after bed rest and training. Circulation, 38(Suppl.7).

Savage,R. (1957). Nonparametric statistics. Journal of the American Statistical Association, 52:332-342.

Sayers,M.H.; Mitchell,M.M.; Renzetti,A.D. (1970). Pulmonary Function Laboratory Manual. Instrumentation and Procedures of Pulmonary Function Testing. Salt Lake City, Utah.

Scheuer,J. and Tipton,C.M. (1977). Cardiovascular adaptations to physical training. Annals of Reviews in Physiology, 39:221-251.

Schnabel,A.; Kindermann,W.; Schmitt,W.M.; Biro,G.; Stegmann,H. (1982). Hormonal and metabolic consequences of prolonged running at the individual anaerobic threshold. International Journal of Sports Medicine, 3:163-168.

Segal,S.S. and Brooks,G.A. (1979). Effects of glycogen depletion and workload on postexercise O_2 consumption and blood lactate. Journal of Applied Physiology, 47:512-514.

Sharkey,B.J. (1970). Intensity and duration of training and the development of cardio-respiratory endurance. Medicine and Science in Sports, 2:197-202.

Sharp,R.L.; Costill,D.L.; Fink,W.J. and King,D.S. (1986). Effects of eight weeks of bicycle ergometer sprint training on human muscle buffer capacity. International Journal of Sports Medicine, 7:13-17.

Sigma Chemical Company (1981). The quantitative determination of pyruvic acid lactic acid. Sigma Technical Bulletin, No. 826-Uv, June.

Siskind,S.J.; S.J.; Sonnenblick,E.M.; Forman,R.; Schner,J.;

LeJentel,T.H. (1980). Acute substantial benefit of inotropic therapy with amrinone on exercise hemodynamics and metabolism in severe congestive heart failure. *Circulation*, 64:966-973.

Sinning,W.E.; Dolny,D.G.; Little,K.D.; Cunningham,L.N.; Racaniello,A.; Siconolfi,S.F. and Sholes,J.L. (1985). Validity of "generalized" equations for body composition analysis in male athletes. *Medicine and Scien in Sports and Exercise*, 17(1):124-130.

Sinning,W.E. and Wilson,J.R. (1984). Validity of "generalized" equations for body composition analysis in women athletes. *Research Quarterly for Exercise and Sports*, 55(2):155-160.

Sjodin,B. and Jacobs,I. (1981). Onset of blood lactate accumulation and marathon running performance. *International Journal of Sports Medicine*, 2(1):23-26.

Sjodin,B.; Jacobs,I.; Svedenhag,J. (1982). Changes in onset of blood lactate accumulation (OBLA) and muscle enzymes after training at OBLA. *European Journal of Applied Physiology*, 49:45-57.

Skinner,J.S.; Holloszy,J.O.; Cureton,T.K. (1964). Effects of a program of endurance exercises on physical work capacity and anthropometric measurements of 15 middle-aged men. *American Journal of Cardiology*, 14:747-752.

Skinner,J.S. and McLellan,T.M. (1980). The transition from aerobic to anaerobic metabolism. *Research Quarterly for Exercise and Sport*, 51(1):234-248.

Sloan,A.W. (1962). Estimation of body fat in young men. *Journal of Applied Physiology*, 17(967-970.

Smith,U.; Hammarsten,J.; Bjorntorp,P.; Kral,J. (1979). Regional differences and effect of weight reduction on human fat cell metabolism. *European Journal of Clinical Investigation*, 9:327-332.

Smith,D.A. and O'Donnell,T.V. (1984). The time course during 36 weeks' endurance training of changes in VO_2 max. and anaerobic threhold as determined with a new computerized method. *Clinical Science*, 67:229-236.

Smith,J.F. and Mansfield,R. (1984). Body composition in university football players. *Medicine and Science in Sports and Exercise*, 16(4):398-405.

Smith,B.W.; McMurray,R.G.; Symanski,J.D. (1984). A comparison of the anaerobic threshold of sprint and endurance trained swimmers. *Journal of Sports Medicine*, 24:94-99.

Smith,M.P.; Mendez,J.; Druckenmiller,M. and Kris-Etherton,P.M. (1982). Exercise intensity, dietary intake, and high density lipoprotein cholesterol in young female competitive swimmers. American Journal of Clinical Nutrition, 36:251-255.

Smith,D.P. and Stransky,F.W. (1976). The effect of training and detraining on the body composition and cardiovascular response of young women to exercise. Journal of Sports Medicine and Physical Fitness, 16:112-120.

Smith,D.J. and Wenger,H.A. (1981). The 10 day aerobic mini-cycle: the effects of interval training or continuous training at two different intensities. Journal of Sports Medicine and Physical Fitness, 21(4):390-394.

Sprynarova,S. and Parizkova,J. (1965). Journal of Applied Physiology, 20:934-937.

Stamford,B.A.; Weltman,A.; Fulco,C. (1978). Anaerobic threshold and cardiovascular responses during one- versus two-legged cycling. Research Quarterly, 409:351-362.

Steel,S.J. (1972). Lung biopsy with high speed drill. British Journal of Hospitalar Medicine, 7:735.

Stegmann,H.; Kindermann,W.; Schnabel,A. (1981). Lactate kinetics and inidividual anaerobic threshold. International Journal of Sports Medicine, 2:160-165.

Stegmann,H. and Kindermann,W. (1982). Comparison of prolonged exercise tests at the individual anaerobic threshold and the fixed anaerobic threshold of 4 mmol.1-1. lactate. International Journal of Sports Medicine, 3:105-110.

Steingrimsdottir,L.; Brasel,J.; Greenwood,M.R.C. (1980). Hormonal modulations of adipose tissue lipoprotein lipase may alter food intake in rats. American Journal of Physiology, 239:E162-E167.

Tanaka,K. and Matsuura,Y. (1984). Marathon performance, anaerobic threshold, and onset of blood lactate accumulation. Journal of Applied Physiology, 57:640-643.

Tanaka,K.; Matsuura,Y.; Moritani,T. (1981). A correlational analysis of maximal oxygen uptake and anaerobic thresholds as compared with middle and long distance performance. Journal of Physical Fitness of Japan, 30:94-102.*

Tanaka,K.; Nakamodo,F.; Kumagai,S. and Nishizumi,M. (1987). Clinical application of lactate threshold to the treatment of obesity. Journal of Human Ergology, 16:145-150.

Tanaka,K.; Watanabe,H.; Konishi,Y.; Mitsuzono,R.; Sumida,S.; Tanaka,S.; Fukuda,T.; Nakadomo,F. (1986). Longitudinal associations between anarobic threshold and distance running performance. European Journal of Applied Physiology, 55:248-252.*

Thomas,T.R.; Adeniran,S.B.; Eltheridge,G.L. (1984). Effects of different running programs on VO_2max, percent fat and plasma lipids. Canadian Journal of Applied Sport Sciences, 9(2):55-62.

Thompson,C.W. (1959). Changes in body fat, estimated from skinfold measuremnts of varsity college football players during a season. Research Quarterly, 30:87-93.

Thompson,C.W.; Buskirk,E.R.; Goldman,R.F. (1956). Changes in body fat, estimated from skinfold measurements of college basketball and hockey players during a season. Research Quarterly, 27:418-430.

Thompson,J.K.; Jarvie,G.J.; Lahey,B.B.; Cureton,K.J. (1982). Exercise and obesity: etiology, physiology, and intervention. Psychology Bulletin, 91:55-79.

Thorland,W.; Sady,S.; Refsell,M. (1980). Anaerobic threshold and maximal oxygen consumption rates as predictors of cross-country running performance. Medicine and Science in Sports and Exercise, 12:87. (Abstract).*

Timson,B. and Cofman,J.L. (1984). Body composition by hydrostatic weighing at total lung capacity and residual volume. Medicine and Science in Sports and Exercise, 16(4):411-414.

Tirnay,S.; Dujardin,J.; Devanne,R.; Petit,J.M. (1971). Muscular exercise during intoxication by carbon monoxide. Journal of Applied Physiology, 31:573-575.

Titchenal,C.A. (1986). The effect of marathon training and detraining on dietary habits and body composition of previously untrained middle-aged men. Unpublished Doctoral Dissertation, University of California, Davis.

Titchenal,C.A. (1988). Exercise and food intake - What is the relationship. Sports Medicine, 6:135-145.

Toriola,A.L. (1984). Influence of 12-week jogging on body fat and serum lipids. British Journal of Nutrition, 18(1):13-17.

Tremblay,A.; Despres,J.P and Bouchard,C. (1985). The effects of exercise training on energy balance and adipose tissue morphology and metabolism. Sports Medicine, 2:223-233.

Turcotte,L.; Byrnes,W.; Frykman,P.; Freedson,P.; Katch,F. (1984). The effects of hydraulic resistive training on maximal oxygen uptake and anaerobic threshold. Medicine and Science in Sports and Exercise, 16(2):183 (abstract).

Twentyman,O.P.; Disley,A.; Gribben,H.R.; Alberti,K.G.M.; Tatersfield,A.E. (1981). Effect of ß-adrenergic blockade on respiratory and metabolic responses to exercise. Journal of Applied Physiology, 51:788-793.

Vogel,J.A. and Gleser,M.A. (1972). Effect of carbon monoxide on oxygen transport during exercise. Journal of Applied Physiology, 32:234-239.

Volz,P.A. and Ostrove,S.M. (1984). Evaluations of a portable ultrasonoscope in assessing the body composition of college-age women. Medicine and Science in Sports and Exercise, 16(1):97-102.

Walsh,M.L. and Banister,E.W. (1988). Possible mechanisms of the anaerobic threshold - a review. Sports Medicine, 5:269-302.

Wang,L.C.H.; Man,S.F.P. and Belcastro,A. (1987). Metabolic and hormonal responses in theophylline-increased cold resistance in males. Journal of Applied Physiology, 63(2):589-596.

Wasserman,K. (1978). Breathing during exercise. New England Journal of Medicine, 298:780-785.

Wasserman,K.; Beaver,W.L.; Davis,J.A.; Bu,J.; Heber,D.; Whipp,B.J. (1985). Lactate, pyruvate and lactate/pyruvate ratio during exercise and recovery. Journal of Applied Physiology, 59: 935-940.

Wasserman.K. and McIlroy,M.B. (1964). Detecting the threshold of anaerobic metabolism in cardiac patients during exercise. American Journal of Cardiology, 14:844-852.

Wasserman,K.; Van Kessel,A.L.; Burton,G.G. (1967). Interaction of physiological mechanisms during exercise. Journal of Applied Physiology, 22:71-85.

Wasserman,K.; Whipp,B.J.; Koyal,S.N.; Beaver,W.L. (1973). Anaerobic threshold and respiratory gas exchange during exercise. Journal of Applied Physiology, 35:236-243.

Wasserman,K.; Whipp,B.J.; Koyal,S.N.; Gleary,M.G. (1976). Effect of carotid body resection on ventilatory and acid-base control during exercise. Journal of Applied Physiology, 39:354.

Weber,K.T.; Kinasewitz,G.T.; Janicki,J.S.; Fishman,A.P. (1982). Oxygen utilization and ventilation during exercise in patients with chronic cardiac failure. Circulation, 65:1213-1223.

Welch,H.G.; Bonde-Petersen,F.; Graham,T.; Clausen,K.; Secher,N. (1977). Effects of hyperoxia on leg blood flow and metabolism during exercise. Journal of Applied Physiology, 44:385-390.

Weltman,A. and Katch,V.L. (1979). Relationship between the onset of metabolic acidosis (anaerobic threshold) and maximal oxygen uptake. Journal of Sports Medicine, 19:135-142.

Weltman,A.; Katch,V.L.; Sady,S.; Freedson,P. (1978). Onset of metabolic acidosis (anaerobic threshold) as a criterion measure of submaximum fitness. Research Quarterly, 49:218-227.

Wenger,H.A. and Bell,G.J. (1986). The interactions of intensity, frequency and duration of exercise training in altering cardiorespiratory fitness. Sports Medicine, 3:346-356.

Wenger,H.A. and Macnab,R.B.J. (1975). Endurance training: the effects of intensity, total work, duration and initial fitness. Journal of Sports Medicine and Physical Fitness, 15(3): 199-211.

Whipp,B.J; Davis,J.A.; Torres,F. and Wasserman,K. (1981). A test to determine parameters of aerobic function during exercise. Journal of Applied Physiology, 50(217-222).

Whipp,B.J. and Wasserman,K. (1972). Oxygen uptake kinetics for various intensities of constant-load work. Journal of Applied Physiology, 33:351-356.

Wilcox,A.R.; Upton,D.E.; Clarkson,P.M.; Katch,F.I.; Lane,R. (1981). Adipose cell size of distance runners before and after a 23 mile run. Journal of Sports Medicine and Physical Fitness, 21(1):1-6.

Williams,C.G.; Windham,C.H.; Kok,R.; Von Rahden, M.J.F. (1967). Effect of traianing on maximum oxygen intake and on anaerobic metabolism in man. International Z. Angew Physiology, 24:18-23.

Wilmore,J.H. (1973). Exercise-induced alterations in weight of overweight women. Archives of Physical Medicine and Rehabilitation, 54:115-119.

Wilmore,J.H. (1974). Alterations in strength, body composition and anthropometric measurements consequent to a 10-week training program. Medicine and Science in Sports, 6:133-138.

Wilmore,J.H. (1983). Body composition in sport and exercise: directions for future research. Medicine and Science in Sports and Exercise, 15(1):21-31.

Wilmore,J.H.; Davis,J.A.; O'Brien,R.S.; Vodak,P.A.; Wlader,G.R.; Amsterdam,E.A. (1980). Physiological alterations consequent to 20-week conditioning programs of bicycling, tennis, and jogging. Medicine and Science in Sports, 12:1-8.

Wilmore,J.H.; Parr,R.B.; Girandola,R.N. (1978). Physiological alterations consequent to circuit training. Medicine and Science in Sports, 10:79-84.

Wilmore,J.H; Royce,J.; Girandola,R.N.; Katch,F.I.; Katch,V.L. (1970). Body composition changes with a 10-week program of jogging. Medicine and Science in Sports, 2;113-117.

Withers,R.T.; Sherman,W.M.; Miller,J.M.; Costill,D.L. (1981). Specificity of the anaerobic threshold in endurance trained cyclists and runners. European Journal of Applied Physiology, 47:93-104.

Winer,B.J. (1962). Statistical Principles in Experimental Design. McGraw-Hill Book Company, Toronto.

Woodson,R.D.; Willis,R.E.; Lenfant,C. (1978). Effect of acute and established anemia on O_2 transport at rest, submaximal and maximal work. Journal of Applied Physiology, 44:36-43.

Yeh,M.P.; Gardner,R.M.; Adams,T.D.; Yanowitz,F.G.; Crapo,R.O. (1983). Anaerobic threshold: problems of determination and validation. Journal of Applied Physiology, 55:1178-1186.

Yoshida,T. (1984). Effect of exercise durationduring incremental exercise on the determination of anaerobic threshold and the onset of blood lactate accumulation. European Journal of Applied Physiology, 53:196-199.

Yoshida,T.; Nagata,A.; Muro,M.; Takeuchi,N.; Suda,Y. (1981). The validity of anaerobic threshold determination by a Douglas bag method compared with arterial blood lactate concentration. European Journal opf Applied Physiology, 46:423-430.

Yoshida,T.; Suda,Y.; Takeuchi,N. (1982). Endurance training regimen based upon arterial blood lactate: effects on anaerobic threshold. Journal of Applied Physiology, 49:223-230.

Yoshitake,Y.; Zaiki,N.; Shinkai,S.; Hino,S. and Watanabe,T. (1987). Journal of Human Ergology, 16:137-143.

Zuti,W.B. and Golding,L.A. (1976). Comparing diet and exercise as weight reduction tools. Physician and Sportsmedicine, 4(1):49-53.

APPENDIX A

Table 1 - Summary of studies that utilised gas exchange measurements to identify AT.

STUDY	*CRITERIA FOR DETERMINATION*	*MEASUREMENT*	*TERM*
Wasserman and McIlroy, 1964	*- Increase in RER*	*Measured bxb with the last 30 seconds of workload used*	*AT*
Wasserman et al., 1973	*- Deviation from linearity for* VCO_2 *and Ve when compared to rate of* VO_2 *increase*	*bxb*	*AT*
Davis et al., 1976	*- Point of departure from linearity in Ve and* VCO_2 *and abrupt increase in RER* *- Abrupt increase in* FeO_2	*Measured every 15 seconds*	*AT*
Davis et al., 1979	*- Systematic increase in* VE/VO_2 *without increase in* VE/VO_2 *- Systematic increase* $PetO_2$ *without decrease in* $PetCO_2$	*bxb*	*AT*
Reinhard et al., 1979	*- At:* V_E/VO_2, FeO_2 *reaches minimum* *- TDMA:* VCO_2 *reaches minimum*	*Mean values for each minute*	*AT and TDMA*
Weltman and Katch, 1979	*- Nonlinear increase in* V_E	*Measured every minute*	*AT*
Ivy et al., 1980	*- Nonlinear increase in Ve*	*Measured every minute*	*LT*
Rusko et al., 1980	*- Nonlinear increase in* V_E	*Measured every 30 seconds*	*AT*

Note: AT (Anaerobic Threshold), AeT (Aerobic Threshold), LT (Lactate Threshold), TDMA (Threshold of Decompensated Metabolic Acidosis), ATge (Gas Exchange Anaerobic Threshold), VT (Ventilatory Threshold), VAT (Ventilatory Anaerobic Threshold), ATve/vo2 ($V_E/VO2$ *Anaerbic Threshold), ATve (*V_E *Anaerobic Threshold), VT1 (Ventilatory Threshold One), VT2 (Ventilatory Threshold Two), bxb (Breath by Breath).*

(Table 1 - Continued)

STUDY	CRITERIA FOR DETERMINATION	MEASUREMENT	TERM
Davis and Gass, 1981	- Systematic increase in V_E/VO_2 without systematic increase in V_E/VCO_2. Point of departure was determined from lowest FeO_2 by a progressive increment in FeO_2	Measured every minute	AT
Ivy et al., 1981	- Nonlinear increase in V_E	Measured every 30 seconds	LT
Whiters et al., 1981	- Increase in V_E/VO_2 with no increase in V_E/VCO_2	Measured every 15 seconds	AT
Yoshida et al., 1981	- Systematic increase in V_E/VO_2 with no change in V_E/VCO_2 - Abrupt increase in FeO_2, RER, and nonlinear increase in V_E and VCO_2		ATge
Caiozzo et al., 1982	- Comparison of several indices: a) Nonlinear increase in V_E; b) Nonlinear increase in VCO_2 c) Abrupt systematic increase in RER d) Systematic increase in V_E/VO_2 without a concomitant increase in V_E/VCO_2	Measured every 30 seconds	AT
Hughes et al., 1982	- Nonlinear increase in V_E when plotted against work rate assessed by 2 referees	Gas collected at second minute of each workload	VT

(Table 1 - Continued)

STUDY	CRITERIA FOR DETERMINATION	MEASUREMENT	TERM
Kumagai et al., 1982	- Nonlinear increase in V_E and VCO_2 - Abrupt increase in FeO_2 - Abrupt increase in RER - Systematic increase in V_E/VO_2 with no change in V_E/VO_2		AT
Mickelson and Hagerman, 1982	- Nonlinear inflection in V_E and VCO_2 - Sudden decrease FeO2 differences	Averaged over one minute intervals	AT
Orr et al., 1982	- Determined by multiple linear regression program - Determined by four investigators using point of departure from the best line drawn for V_E vs VO_2	Calculated every 15 seconds	AT
Ready and Quinney, 1982	- Systematic increase in V_E/VO_2 without increase in V_E/VCO_2, determined mathematically - Changes in V_E, FeO_2 and R in relation to power $PetCO_2$	Measured every 30 seconds	AT
Becker and Vaccaro, 1983	- Increase in V_E/VCO_2, without increase in V_E/VCO_2 - Increase in $PetO_2$ without decrease in $PetCO_2$	bxb	AT
Bhambhani et al., 1984	- Point where V_E/VO_2 reached minimum - Point where V_E/VCO_2 reached minimum	Measured every 30 seconds	AT and TDMA

(Table 1 - Continued)

STUDY	CRITERIA FOR DETERMINATION	MEASUREMENT	TERM
Davis et al., 1983	- Systematic increase in V_E/VO_2 without concomitant increase in V_E/VCO_2	Measured every 30 seconds	AT
Dwyer and Bybee, 1983	- V_E, V_E/VO2, VCO_2, RER depart from linearity in relation to O2	Averaged over 30 second intervals	AT
Fairshter et al., 1983	- Abrupt and systematic increase in V_E/VO_2 without increase in V_E/VCO_2	Gas collected bxb and reported for 15 second periods	AT
Gibbons et al., 1983	- Nonlinear increase in V_E - Nonlinear increase in VCO_2 - Increase in % $PetO_2$ without corresponding decrease in RER	Measured every 30 seconds	AT
Green et al., 1983	- Initial breakpoint in V_E/VO_2 determined by computer algorithm technique employing multisegmental linear regression	Calculated for two consecutive 15 second periods at the end of 30 seconds of workload	VAT
Yeh et al., 1983	- Systematic increase in V_E/VO_2 without increase in V_E/VCO_2 - Systamatic increase in $PetO_2$ without decrease in $PetCO_2$	Measured bxb with average of 4 breaths used	AT

(Table 1 - Continued)

STUDY	CRITERIA FOR DETERMINATION	MEASUREMENT	TERM
Aunola and Rusko, 1984	- AeT: first nonlinear increase in Ve and VCO_2 as compared to VO_2 - AT: point where the linearity in V_E/VO_2 and V_E/work rate curves markedly disappears usually for the second time. Assessed by 2 investigators	Collected bxb with values displayed every 30 seconds	AeT and AT
Black et al, 1984	- When higher number of points were obtained. a) increase in V_E/VO_2 without increase in $FeCO_2$ - 3; b) decrease in FeO2 without decrease in $FeCO_2$ - 3; c) progressive increment of V_E/VCO_2 - 2; d) moment precedinf the breaking point in V_E - 1; e) RER started to increase steeply - 1	Measured every 30 seconds	AeT
Gaesser et al., 1984	- Systematic increase in V_E/VO_2 without increase in V_E/VCO_2	bxb	VT
Golden and Vacarro, 1984	- Departure from linearity for V_E - Increase in V_E/VO_2 without increase in V_E/VCO_2	Measured every 12 seconds	AT

(Table 1 - Continued)

STUDY	*CRITERIA FOR DETERMINATION*	*MEASUREMENT*	*TERM*
Nikolic and Todorovic, 1984	*- Nonlinear increase in V_E*	*V_E was measured every minute and VO_2 max was predicted by the Astrand-Rhyming nomogram*	*AT*
Powers et al., 1984	*- Determined by single blind two evaluators:* *a) Systematic increase in V_E/VO_2 with no change in V_E/VCO_2;* *b) Nonlinear increase in V_E;* *A third investigator arbitrated in case of difference*	*Values recorded for the last minute of each workload*	*AT* *$V_E/VO2$*
Prud'Homme et al., 1984	*- Identified as the first and second nonlinear increase in V_E relative to VO_2* *- Identified as the first and second nonlinear increase in V_E/VO_2 relative to VO_2* *Assessed by three investigators*	*bxb*	*VT1 and VT2*
Rhodes and McKenzie, 1984	*- Excess VCO_2 curve $[VCO_2-(RER*VO_2)]$*	*Measured every 15 seconds*	*AT*
Smith et al., 1984	*- Disproportional break point in V_E and the simultaneous rapid decrease in $FeCO_2$* *- Disproportional increase in V_E/VO_2*	*Measured at last minute of each workload*	*AT*
Bhambhani and Singh, 1985	*- V_E/VO_2 and $FeCO_2$ reaches minimum*	*Measured every 30 seconds*	*AT and TDMA*

(Table 1 - Continued)

STUDY	CRITERIA FOR DETERMINATION	MEASUREMENT	TERM
Gladden et al., 1985	- Nine evaluators used the method discussed by Davis et al, (1976) and Caiozzo et al, (1982) - V_E vs time was analysed by computer generated linear regression. AT was identified as the first intersection point of the appropriate lines	Measured every 15 seconds	AT
McLellan, 1985	- VT1: a) First increase in V_E/VO_2 with no change in V_E/VCO_2; b) Estimated by plots of excess CO_2 vs VO_2 - VT2: a) V_E vs VO_2 and increase in V_E/VCO_2; b) change in pattern of response of ln V_E/VCO_2 when plotted against VO_2	Measured every 30 seconds	VT1 and VT2
Neary et al., 1985	- Nonlinear increase in V_E vs VO_2 determined by a linear regression	Measured every 30 second	VT
Neary and Wenger, 1985 a,b,c	- Nonlinear increase in V_E determined by linear regression model	Measured every 30 seconds	VT
Poole and Gaesser, 1985	- Systematic increase in V_E/VO_2 without increase in V_E/VCO_2	bxb	VT

(Table 1 - Continued)

STUDY	CRITERIA FOR DETERMINATION	MEASUREMENT	TERM
Reybrouck et al., 1985	- Nonlinear increase in V_E - Nonlinear increase in VCO_2 - Systematic increase in V_E/VO_2 without concomitant increase in V_E/VCO_2 - Progressive increase in FeO_2 - Excessive rise in RER	Measured every minute	VAT
Anuola and Rusko, 1986	- AeT: nonlinear increase in V_E and VCO_2 - AT: second nonlinear increase in V_E and VCO_2 - Mathematically identified by V-SLOPE method - Also identified by 6 investigators: a) increase in V_E/VO_2 change or decrease in V_E/VCO_2; b) $PetCo_2$ slowly rising or constant with increase in $PetO_2$; c) more positive slope of RER/work rate curve	Measured bxb with 30 period values used	AeT and AT
Bunc et al., 1986	- Increase in V_E and VCO_2 determined by a two-part discontinuous linear model	Measured every 30 seconds	AT
Foster et al., 1986	- Point where the relationship between VO_2 and V_E began to increase exponentially	Measured at the last minute of each workload	VT

(Table 1 - Continued)

STUDY	CRITERIA FOR DETERMINATION	MEASUREMENT	TERM
Reybrouck et al., 1986	- Nonlinear increase in V_E - Systematic increase in V_E/VO_2 - Nonlinear increase in VCO_2 - Excess rise in RER	Average of one minute intervals	VT
Rusko et al., 1986	- Determined visually by two investigators. AeT: first time change in linearity in the V_E/VO_2 and V_E/Power output curves; AT: when linearity disappeared for second time	Measured every 30 seconds	AeT and AT

Table 2 - Summary of studies dealing with body fat and or weight reduction in adult males as a result of training

STUDY	AGE	PROGRAM DURATION (WEEKS)	SESSION DURATION (MIN.)	FREQUENCY (D/WK)	MODE *	PRE WEIGHT % FAT	POST WEIGHT %FAT
Thompson et al., 1956	21	-	-	-	5	81.1 9.2	80.2 7.7
Thompson et al., 1956	21	-	-	-	6	71.6 8.4	71.2 6.9
Thompson et al., 1959	21	-	-	-	7	88.8 8.2	87.3 6.5
Skinner et al., 1964	42	26	40	6	1.3	79.6 20.0	79.7 17.5
Oscai et al., 1965	37	16	30	3	1	79.5 23.3	77.1 21.1
Oscai and Williams, 1968	35-46	16	30	3	1	88.1 26.8	83.6 23.9
Carter and Phillips, 1969	39-59	104	60	2-3	1	80.3 19.8	77.0 18.6
Kilbom et al., 1969	40	8-10	-	2-3	1.3	77.9 24.5	78.2 24.8
Pollock et al., 1969	28-39	20	30	2	1	80.2 18.0	80.3 18.9
Pollock et al., 1969	28.39	20	30	4	1	79.7 19.6	76.8 18.6
Pollock et al., 1969	37	16	30	4	1	79.4 20.7	78.5 17.4
Pollock et al., 1969	37	16	30	2	1	80.6 22.8	79.8 23.2

*Mode: (1) walk, jog, run (2) cycle ergometer (3) calisthenics (4) weight training (5) basketball (6) hockey (7) football (8) tennis

(Table 2 - Continued)

STUDY	AGE	PROGRAM DURATION (WEEKS)	SESSION DURATION (MIN.)	FREQUENCY (D/WK)	MODE *	PRE WEIGHT % FAT	POST WEIGHT %FAT
Ribisl, 1969	40	22	35	3	1.3	84.4 21.4	81.9 20.7
Wilmore et al., 1970	33	10	20	3	1	79.6 18.9	78.6 17.8
Boileau et al., 1971	18	9	60	5	1	122.4 38.5	119.2 34.5
Boileau et al., 1971	18	9	60	5	1	67.6 15.1	66.6 12.1
Pollock et al., 1971	49	20	40	4	1	77.6 22.0	76.3 20.9
Kollias et al., 1972	18	9	-	5	1	67.7 14.4	67.0 11.5
Kollias et al., 1972	18	9	-	5	1	122.4 38.5	119.2 34.6
Pollock et al., 1972	39	20	45	2	1	81.3 23.3	80.4 22.9
Pollock et al., 1972	39	20	45	2	1	79.4 22.9	78.7 22.1
Girandola and Katch, 1973	21	9	-	2	4	77.2 16.9	76.9 15.9
Misner et al., 1974	38	8	30	3	1	84.7 27.9	83.9 25.4
Misner et al., 1974	38	8	30	3	4	86.2 25.9	87.2 23.1

(Table 2 - Continued)

STUDY	AGE	PROGRAM DURATION (WEEKS)	SESSION DURATION (MIN.)	FREQUENCY (D/WK)	MODE *	PRE WEIGHT % FAT	POST WEIGHT %FAT
Wilmore et al., 1974	20	10	40	2	4	72.9 13.2	73.3 11.9
Fahey et al., 1975	-	9	-	3	4	76.6 15.1	77.1 14.1
Pollock et al., 1975	38	20	30	3	1	84.7 21.7	83.4 20.4
Pollock et al., 1975	38	20	30	3	1	85.2 22.4	83.9 19.4
Pollock et al., 1975	38	20	30	3	2	84.1 21.0	82.9 19.8
Pollock et al., 1976	55	20	30	3	1	79.1 21.4	77.9 19.8
Gettman et al., 1978	21-35	20	45	3	4	85.4 24.4	85.9 22.7
Gettman et al., 1978	21-35	20	45	3	1	82.1 21.7	81.6 19.1
Wilmore et al.,	20	10	25	3	4	71.9 16.8	71.9 16.4
Garfield et al., 1979	23	12	15-33	3	4	77.6 13.5	76.9 11.6
Gettman et al., 1979	29	16	25	3	1.4	80.5 20.2	80.1 18.7
Wilmore et al., 1980	29	20	30	3	8	88.3 21.9	87.4 21.8

(Table 2 - Continued)

STUDY	AGE	PROGRAM DURATION (WEEKS)	SESSION DURATION (MIN.)	FREQUENCY (D/WK)	MODE *	PRE WEIGHT % FAT	POST WEIGHT %FAT
Wilmore et al., 1980	37	20	30	3	2	85.7 21.2	85.3 19.6
Wilmore et al., 1980	36	20	30	3	1	79.8 17.8	77.9 17.8
Thomas et al., 1984	18-32	12	30-32	3	1	- 16	- 14
Thomas et al., 1984	18-32	12	30-32	3	1	- 14.0	- 12.0
Thomas et al., 1984	18-32	12	30-32	3	1	- 17.5	- 13.0
Toriola, 1984	24.1	12	15-20	3	1	- 16.8	- 15.8
Toriola, 1984	24.1	12	22-28	3	1	- 16.5	- 15.7
Toriola, 1984	24.1	12	28-35	3	1	- 17.0	- 15.6
Depres et al., 1984a	23.4	20	40-45	5	2	55.9 23.2	56.7 20.6
Depres et al., 1984b	26.3	20	40	5	2	72.3 18.8	69.4 15.6
Depres et al., 1985	24.3	20	40-45	4-5	2	72.1 17.3	69.7 14.6

APPENDIX B

Table 3 - Schedule for exercise testing and training sessions (numbers in Activity column denote training days)

	ACTIVTY		WEEK #
	PRE TESTING		0
1	2	3	1
4	5	6	2
7	8	9	3
10	11	12	4
13	14	15	5
16	17	18	6
19	20	21	7
22	23	24	8
25	26	27	9
28	29	30	10
31	32	33	11
34	35	36	12
	POST TESTING		13

Note: weeks 0 and 13 are reserved for Pre and Post Tests for all subjects. Days 9, 18, and 27 are reserved for reassessment of workloads for the experimental groups. No training will take place on these days. In days 6 and 36, blood samples will be taken during the training session.

Table 4 - Method of equating the total amount of Work performed by each subject in the same rank

TRAINING GROUP	*TRAINING POWER OUTPUT (kpm/min)*	*DURATION OF EXERCISE (min:sec)*	*TOTAL WORK PERFORMED (kpm)*
VTG	*1400*	*20:00*	*28000*
BTVG	*1000*	*28000 / 1000 - 28:00*	*1000 X 28:00 - 28000*
ITG	*1600*	*28000 / 1600 - 17:30*	*1600 X 17:30 - 28000*

Note: Training Power Output was determined by means of a progressive maximum exercise test. All calculations were based on the Ventilatory Threshold Group (VTG).

APPENDIX C

Table 5 - Characteristics of the subjects at the beginning of the study (complete sample , n-39)

GROUP		AGE (yr)	HEIGHT (cm)	WEIGHT (kg)	VO_2 MAX ($ml.kg.min^{-1}$)
VTG (n-11)	Mean	34.20	177.90	84.44	42.11
	Sd	7.33	5.99	9.97	6.81
	Sem	2.21	1.81	3.01	2.05
	Max	47.00	188.00	111.40	53.20
	Min	25.00	169.50	71.90	29.70
BVTG (n-11)	Mean	41.64[1]	175.94	84.41	40.28
	Sd	9.38	4.18	8.08	7.90
	Sem	2.83	1.26	2.43	2.38
	Max	54.00	185.50	103.00	51.30
	Min	23.00	170.50	72.20	25.80
ITG (n-11)	Mean	38.80[1]	177.10	83.30	41.34
	Sd	5.15	7.55	12.08	7.73
	Sem	1.55	2.28	3.64	2.33
	Max	48.00	191.00	101.50	55.30
	Min	29.00	168.50	59.40	29.10
CG (n-6)	Mean	27.83	178.58	78.52	45.33
	Sd	5.96	6.45	3.97	5.59
	Sem	2.43	2.63	1.62	2.28
	Max	39.00	186.00	86.10	55.30
	Min	20.00	169.50	73.20	38.70

VTG - ventilatory threshold group
BVTG - below ventilatory threshold group
ITG - interval training group
CG - control group

[1] - sig. different from CG ($p < .05$)

Table 6 - Characteristics of the subjects with complete data, at the beginning of the study (n=31).

GROUP		AGE (yr)	HEIGHT (cm)	WEIGHT (kg)	VO_2 MAX ($ml.kg.min^{-1}$)
VTG	Mean	36.14	180.86	87.86[1]	40.97
(n=8)	Sd	7.24	4.56	9.93	7.12
	Sem	2.56	1.61	3.51	2.52
	Max	47.00	188.00	111.40	53.20
	Min	26.00	172.50	81.50	29.70
BVTG	Mean	42.40[1]	175.38	84.35[1]	39.28
(n=10)	Sd	9.51	3.98	8.47	7.59
	Sem	3.01	1.26	2.68	2.40
	Max	54.00	185.50	103.00	51.30
	Min	23.00	170.50	72.20	25.80
ITG	Mean	39.86[1]	172.79	77.43	41.60
(n=7)	Sd	7.55	3.10	9.66	9.44
	Sem	2.85	1.17	3.65	3.57
	Max	51.00	177.00	90.00	55.30
	Min	29.00	168.50	59.40	26.00
CG	Mean	27.83	178.58	78.52	45.33
(n=6)	Sd	5.96	6.45	3.97	5.59
	Sem	2.43	2.63	1.62	2.28
	Max	39.00	186.00	86.10	55.30
	Min	20.00	169.50	73.20	38.70

VTG - ventilatory threshold group
BVTG - below ventilatory threshold group
ITG - interval training group
CG - control group

1 - sig. different from CG ($p < .05$)

Table 7 - Characteristics of the subjects that participated in the test/retest reliability of the ventilatory threshold two study (n=7).

	AGE (yr)	HEIGHT (cm)	WEIGHT (kg)	VO_2 MAX ($l.min^{-1}$)	VO_2 at VT2 ($l.min^{-1}$)
Mean	23.14	180.86	76.10	4.391	2.611
Sd	5.94	8.06	6.55	0.591	0.499
Sem	2.24	3.05	2.47	0.223	0.189
Max	35.00	193.00	86.20	4.989	3.412
Min	25.00	166.00	67.00	3.234	1.788

Table 8 - Test/Retest reliability of the ventilatory threshold (Mean, ± sd), correlation coefficient, coefficient of determination and t-test (n=7).

VARIABLE	TEST	RETEST	r	r^2	t (prob.)
VO_2 $l.min^{-1}$	2.61 (0.54)	2.55 (0.42)	0.87	0.76	0.54
POWER OUTPUT kpm/min	1142.86 (299.20)	1200.00 (230.94)	0.96	0.93	0.17
TIME sec	919.00 (154.51)	927.29 (143.54)	0.98	0.97	0.47
VO_2 (% VO_2 max)	59.65 (9.75)	57.62 (7.26)	0.69	0.47	0.48
HEART RATE bpm	141.29 (15.04)	139.00 (19.35)	0.88	0.79	0.54
HEART RATE (% max)	76.02 (5.56)	75.41 (7.64)	0.78	0.61	0.75

obs.: all variables measured at the ventilatory threshold two.

APPENDIX D

Table 9 - Training power output - P.O. (kpm/min) and Time (min) for the exercising groups throughout the study.

P.O. (kpm/min)		TIME		
GROUP	T 1	T 2	T 3	T 4
VTG	1075.00	1150.00	1225.00^{a}	1325.00^{abc}
BVTG	960.00	960.00	1020.00	1060.00^{ab}
ITG	1685.71	1771.43	1885.71^{ab}	1942.86^{ab}

TIME (min)		TIME		
GROUP	T 1	T 2	T 3	T 4
VTG	20.00	20.00	20.00	20.00
BVTG	22.66	24.40	23.90	24.54
ITG	13.14	13.29	13.57	14.86

a - sig. different from T 1 ($p < .05$)
b - sig. different from T 2 ($p < .05$)
c - sig. different from T 3 ($p < .05$)

Table 10 - Effect of three treatments on selected physiological variables measured at the maximum exercise capacity.

VO_2 (l.min^{-1})		TIME			
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	3.351	3.694^a	3.702^a	3.718^a	3.718^a
BVTG	3.233	3.288	3.263	3.376	3.383
ITG	3.175	3.469^a	3.502^a	3.655^a	3.638^a
CG	3.592				3.435

VO_2 (ml.kg.min^{-1})		TIME			
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	38.80	43.47^a	42.93^a	43.52^a	43.39^a
BVTG	39.00	39.74	39.64	41.21^a	41.24^a
ITG	41.56	45.01^a	45.83^a	47.46^a	47.11^a
CG	45.33				42.87^a

a - sig. different from T 1 ($p < .05$)

Table 11 - Effect of three treatments on selected physiological variables measured at the maximum exercise capacity.

V_E ($l.min^{-1}$)	TIME				
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	129.9	150.5^{a}	144.7^{a}	145.8^{a}	149.8^{a}
BVTG	133.1	140.8	136.9	136.2	140.1
ITG	125.9	143.7^{a}	146.8^{a}	151.9^{a}	148.6^{a2}
CG	141.1				105.1^{a}

VCO_2 ($l.min^{-1}$)	TIME				
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	3.862	4.223^{a}	4.043	4.250^{a}	4.291^{ac}
BVTG	3.861	3.797	3.624	3.870^{c}	3.801
ITG	3.823	3.978	4.016^{ab}	4.308^{a}	4.166^{a}
CG	4.032				3.932

a - sig. different from T 1 ($p < .05$)
b - sig. different from T 2 ($p < .05$)
c - sig. different from T 3 ($p < .05$)
2 - sig. different from CG at T5 ($p < .05$)

Table 12 - Effect of three treatments on selected physiological variables measured at the maximum exercise capacity.

RER	TIME				
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	1.15	1.13	1.09[a]	1.13	1.14
BVTG	1.19	1.15	1.11[a]	1.14	1.15
ITG	1.22	1.15[a]	1.16	1.18	1.15[a]
CG	1.13				1.20[a]

HR (bpm)	TIME				
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	172.5	177.6	177.2	177.9	179.5[a]
BVTG	176.1	173.3	176.6	178.0	177.4
ITG	175.0	179.6	185.1[a]	183.9[a]	181.6
CG	181.5				181.3

a - sig. different from T 1 ($p < .05$)

Table 13 - Effect of three treatments on selected physiological variables measured at the maximum exercise capacity.

P.O. (kpm/min)			TIME		
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	1775.0	1750.0	1850.0^{b}	1950.0^{abc}	1925.0^{ab}
BVTG	1622.2	1622.2	1822.2^{ab}	1822.2^{ab}	1844.4^{ab}
ITG	1685.7	1714.3	1914.3^{ab}	1942.9^{ab}	1942.9^{ab}
CG	1700.0				1600.0

V_E/VO_2			TIME		
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	38.6	40.7	38.8	39.2	40.0
BVTG	41.3	42.7	42.1	40.8	41.6^{2}
ITG	39.9	41.7	42.4	41.8	41.3^{2}
CG	40.2				31.1^{a}

a - sig. different from T 1 ($p < .05$)
b - sig. different from T 2 ($p < .05$)
c - sig. different from T 3 ($p < .05$)
2 - sig. different from CG at T5 ($p < .05$)

Table 14 - Effect of three treatments on selected physiological variables measured at the maximum exercise capacity.

V_E/VCO_2	TIME				
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	33.5	35.4	35.6	34.2	34.6
BVTG	34.6	37.2[a]	38.1[a]	35.7[c]	37.1[a2]
ITG	32.9	36.3[a]	36.5[a]	35.4[a]	35.8[a2]
CG	35.2				27.7[a]

O_2PULSE ($ml.beat^{-1}$)	TIME				
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	19.4	20.8[a]	20.9[a]	20.9[a]	20.8[a]
BVTG	18.3	18.9	18.4	18.9	19.1
ITG	18.2	19.3	18.9	19.9[a]	20.0[a]
CG	19.9				19.1

a - sig. different from T 1 ($p < .05$)
c - sig. different from T 3 ($p < .05$)
2 - sig. different from CG at T5 ($p < .05$)

Table 15 - Effect of three treatments on selected physiological variables measured at the ventilatory threshold two.

VO_2 $(l.min^{-1})$	TIME				
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	2.139	2.559[a]	2.341[b]	2.596[ac]	2.693[ac]
BVTG	2.207	2.315	2.180	2.283	2.200
ITG	2.062	2.410[a]	2.165[b]	2.211	2.308[a]
CG	2.161				2.412

VO_2 $(ml.kg.min^{-1})$	TIME				
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	24.67	30.07[a]	27.11[b]	30.16[ac]	31.60[ac]
BVTG	26.41	27.79	26.37	27.62	26.80
ITG	26.86	31.39[a]	28.21[b]	29.20	30.00[a]
CG	27.12				30.23

a - sig. different from T 1 ($p < .05$)
b - sig. different from T 2 ($p < .05$)
c - sig. different from T 3 ($p < .05$)

Table 16 - Effect of three treatments on selected physiological variables measured at the ventilatory threshold two.

V_E (l.min^{-1})	TIME				
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	52.4	67.3^{a}	60.7	68.5^{ac}	71.5^{ac}
BVTG	58.7	63.0	57.7	60.8	58.6^{2}
ITG	50.3	60.2^{a}	53.4	55.1	57.3^{2}
CG	52.1				59.20

VCO_2 (l.min^{-1})	TIME				
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	2.019	2.429^{a}	2.188	2.622^{ac}	2.651^{ac}
BVTG	2.121	2.169	1.981	2.237	2.060^{2}
ITG	1.944	2.204	1.953	2.153	2.148
CG	2.000				2.421^{a}

a - sig. different from T 1 ($p < .05$)
b - sig. different from T 2 ($p < .05$)
2 - sig. different from VTG at T 5 ($p < .05$)

Table 17 - Effect of three treatments on selected physiological variables measured at the ventilatory threshold two.

RER	TIME				
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	0.94	0.95	0.93	1.01^{abc}	0.98
BVTG	0.98	0.96	0.93	1.00^{c}	0.95
ITG	0.94	0.92	0.91	0.97^{c}	0.94
CG	0.92				1.00^{a}

HR (bpm)	TIME				
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	132.7	142.0	136.6	145.5^{a}	148.7^{ac}
BVTG	138.0	133.0	133.6	138.0	135.3
ITG	140.9	142.9	137.9	137.7	139.0
CG	134.5				146.2

a - sig. different from T 1 ($p < .05$)
b - sig. different from T 2 ($p < .05$)
c - sig. different from T 3 ($p < .05$)

Table 18 - Effect of three treatments on selected physiological variables measured at the ventilatory threshold two.

P.O. (kpm/min)	TIME				
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	1075.0	1150.0	1225.0	1300.0^{ab}	1300.0^{ab}
BVTG	1044.4	1088.9	1088.9	1133.3	1088.9
ITG	1085.7	1171.4	1142.9	1142.9	1114.3
CG	1000.0				1100.0

V_E/VO_2	TIME				
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	24.5	26.4	25.9	26.7^a	26.6^a
BVTG	27.2	27.6	26.9	27.3	27.1
ITG	24.3	25.0	24.7	25.0	24.9
CG	24.5				24.9

a - sig. different from T 1 ($p < .05$)
b - sig. different from T 2 ($p < .05$)

Table 19 - Effect of the three treatments on selected physiological variables measured at the ventilatory threshold two.

V_E/VCO_2			TIME		
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	26.1	27.7^a	27.8^a	26.4^b	27.1
BVTG	27.6	28.8	28.9^a	27.4^{bc}	28.5
ITG	25.8	27.3^a	27.2	25.6^{bc}	26.5
CG	26.5				25.1

O_2PULSE (ml.beat^{-1})			TIME		
GROUP	T 1	T 2	T 3	T 4	T 5
VTG	15.9	18.0^a	17.1^{ab}	17.7^a	18.1^{ac}
BVTG	15.6	16.7^a	15.9	16.2	16.1
ITG	14.6	16.8^a	15.7^{ab}	16.1^a	16.5^a
CG	16.2				16.6

a - sig. different from T 1 ($p < .05$)
b - sig. different from T 2 ($p < .05$)
c - sig. different from T 3 ($p < .05$)

Table 20 - Effect of the three treatments on body composition.

GROUP	VARIABLE	PRE	MID	POST
VTG	WEIGHT (kg)	87.7^1	87.3	87.5
BVTG		84.3^1	83.3^a	82.7^a
ITG		77.4	77.5	77.7
CG		78.5		79.4^a

GROUP	VARIABLE	PRE	MID	POST
VTG	DENSITY ($gm.ml^{-1}$)	1.04359^1	1.04578	1.04349^2
BVTG		1.03725^1	1.03836	1.04283^{ab2}
ITG		1.05040	1.05044	1.05356
CG		1.06542		1.06595

GROUP	VARIABLE	PRE	MID	POST
VTG	FAT (%)	23.8^1	22.9	23.9^2
BVTG		26.4^1	26.0	24.1^{ab2}
ITG		20.9	20.9	19.6
CG		14.8		14.6

a - sig. different from PRE ($p < .05$)
b - sig. different from MID ($p < .05$)
1 - sig. different from CG at PRE ($p < .05$)
2 - sig. different from CG at POST ($p < .05$)

Table 21 - Effect of the three treatments on body composition.

GROUP	VARIABLE	PRE	MID	POST
VTG	FAT (kg)	21.4^{1}	20.4	21.4^{2}
BVTG		22.6^{1}	22.0	20.3^{ab2}
ITG		16.5^{1}	16.6	15.6
CG		11.6		11.6

GROUP	VARIABLE	PRE	MID	POST
VTG	LBM (kg)	66.3	66.9	66.2
BVTG		61.8	61.3	62.4
ITG		61.0	61.0	62.2
CG		66.9		67.8

GROUP	VARIABLE	PRE	MID	POST
VTG	SUM 7 (mm)	105.76	108.04	108.09
BVTG		120.96^{1}	118.19	111.94^{ab}
ITG		96.68	97.10	100.29
CG		69.0		75.46^{a}

a - sig. different from PRE ($p < .05$)
b - sig. different from MID ($p < .05$)
1 - sig. different from CG at PRE ($p < .05$)
2 - sig. different from CG at POST ($p < .05$)

Table 22 - Effect of the three treatments on body composition.

GROUP	VARIABLE	PRE	MID	POST
VTG	TRI (mm)	12.61	12.26	11.99
BVTG		13.64[1]	12.94	12.70[a]
ITG		11.59	11.04	11.06
CG		8.50		8.54

GROUP	VARIABLE	PRE	MID	POST
VTG	SSC (mm)	18.46	18.93	18.27
BVTG		23.20[1]	22.93	21.42[ab]
ITG		16.49	16.83	16.57
CG		11.40		12.40[a]

GROUP	VARIABLE	PRE	MID	POST
VTG	SI (mm)	17.79	18.81	18.94
BVTG		19.03	18.06	17.08[a]
ITG		16.10	14.94	16.97[b]
CG		10.14		12.26[a]

a - sig. different from PRE ($p < .05$)
b - sig. different from MID ($p < .05$)
1 - sig. differen from CG at PRE ($p < .05$)

Table 23 - Effect of the three treatments on body composition.

GROUP	VARIABLE	PRE	MID	POST
VTG	ABD (mm)	26.70	26.10	26.76
BVTG		29.37	28.39	26.16[a]
ITG		22.16	23.07	24.49
CG		16.82		18.74

GROUP	VARIABLE	PRE	MID	POST
VTG	BI (mm)	5.89	6.10	6.40[a]
BVTG		6.79	6.73	6.78
ITG		5.33	5.51	5.53
CG		4.30		4.40

GROUP	VARIABLE	PRE	MID	POST
VTG	THI (mm)	13.64	15.03	15.09
BVTG		18.22[1]	18.61	17.74
ITG		14.96	15.97	16.24
CG		10.92		12.20

a - sig. different from PRE $(p < .05)$
b - sig. different from MID $(p < .05)$
1 - sig. different from CG at PRE $(p < .05)$

Table 24 - Effect of the three treatments on body composition.

GROUP	VARIABLE	PRE	MID	POST
VTG	CAL (mm)	10.70	10.81	10.61
BVTG		10.72	10.56	10.03
ITG		10.07	9.73	9.47
CG		7.14		6.88

Table 25 - Changes in total energy intake.

GROUP	TOTAL INTAKE (Kcal)	PRE	MID	POST
VTG		2770.44	2513.17	2524.16
BVTG		2882.75	2529.27	3001.62
ITG		2536.72	2348.37	2510.07

PRE - baseline value measured before the beginning of the study, and based on average of two three day questionnaires.

Table 26 - Lactate concentration ($mmol.l.^{-1}$) during training at different exercise intensities at the beginning and at the end of the study measured at rest, mid exercise and immediately after exercise.

		CONDITION		
GROUP		REST	MID	POST
VTG	BEG	0.998	4.466^{1}	4.699^{1}
	END	0.906	4.829^{1}	4.045^{1}
VTG	BEG	0.829	3.303^{1}	3.442^{1a}
	END	0.721	3.323^{1a}	3.288^{1}
ITG	BEG	1.281	5.969^{1ab}	7.197^{12ab}
	END	1.009	6.287^{1ab}	7.580^{12ab}

1 - sig. different from REST ($p < .05$)
2 - sig. different from MID ($p < .05$)

a - sig. different from VTG ($p < .05$)
b - sig. different from BVTG ($p < .05$)

obs.: there were no sig. differences between BEG and END in all groups for the PRE, MID or POST conditions.

Table 27 - Free fatty acid concentration (uEq.l.$^{-1}$) during training at different exercise intensities at the beginning and at the end of the study (measured at rest, mid exercise and immediately after).

		CONDITION		
GROUP		REST	MID	POST
VTG	BEG	404.36	412.33	440.94
	END	598.98	607.40	667.61
BVTG	BEG	412.31	430.03	527.75^{12a}
	END	588.01	525.26	743.15^{12}
ITG	BEG	494.38	411.01	570.96^{2}
	END	506.00	499.60	488.27

1 - sig. different from REST ($p < .05$)
2 - sig. different from MID ($p < .05$)

a - sig. different from VTG ($p < .05$)

obs.: there were no sig. differences between BEG and END in all groups for the REST, MID or POST conditions.

Table 28 - Interrelationship between increases in blood lactate and free fatty acid concentrations during training at different exercise intensities, at the beginning and at the end of the study. Correlation coefficients calculated for pooled data.

	BEGINNING OF STUDY (n=24)			END OF STUDY (n=20)		
	La 1	La 2	La 3	La 1	La 2	La3
FFA 1	-.057 p=.396			.185 p=.217		
FFA 2		.252 p=.118			.086 p=.360	
FFA 3						

La 1 = mid exercise - rest
La 2 = end exercise - rest
La 3 = end exercise - mid exercise

FFA 1 = mid exercise - rest
FFA 2 = end exercise - rest
FFA 3 = end exercise - mid exercise

p = sig. level

Table 29 - Interrelationship between increases in blood lactate and free fatty acid concentrations during training at different exercise intensities, at the beginning and at the end of the study. Correlation coefficients calculated for group data.

GROUP VTG	BEGINNING OF STUDY (n=8)			END OF STUDY (n=7)		
	La 1	La 2	La 3	La 1	La 2	La3
FFA 1	.442 p=.136			.501 p=.126		
FFA 2		-.345 p=.201			.379 p=.201	
FFA 3						

La 1 = mid exercise - rest
La 2 = end exercise - rest
La 3 = end exercise - mid exercise

FFA 1 = mid exercise - rest
FFA 2 = end exercise - rest
FFA 3 = end exercise - mid exercise

p = sig. level

Table 29 - (Continued)

GROUP BVTG	BEGINNING OF STUDY (n=9)			END OF STUDY (n=9)		
	La 1	La 2	La 3	La 1	La 2	La3
FFA 1	-.249 p=.259			-.164 p=.337		
FFA 2		.407 p=.139			.492 p=.089	
FFA 3						

La 1 = mid exercise - rest
La 2 = end exercise - rest
La 3 = end exercise - mid exercise

FFA 1 = mid exercise - rest
FFA 2 = end exercise - rest
FFA 3 = end exercise - mid exercise

p = sig. level

Table 29 - (Continued)

GROUP ITG	BEGINNING OF STUDY (n=7)			END OF STUDY (n=4)		
	La 1	La 2	La 3	La 1	La 2	La3
FFA 1	.551 p=.100			-.263 p=.368		
FFA 2		.199 p=.335			.792 p=.104	
FFA 3						

La 1 = mid exercise - rest
La 2 = end exercise - rest
La 3 = end exercise - mid exercise

FFA 1 = mid exercise - rest
FFA 2 = end exercise - rest
FFA 3 = end exercise - mid exercise

p = sig. level

Table 30 - Studies published in the last two decades on the effects of training on maximum oxygen consumption of male subjects.

STUDY	PRE VO_2 (l/min)	POST VO_2 (l/min)	PRE VO_2 (ml/kg/min)	POST VO_2 (ml/kg/min)	TYPE
Denis et al. (1988)	2.94 (±0.48)	3.41* (±0.50)	46.4 (±8.30)	54.4* (±7.90)	CC
Moore et al. (1987)	2.77 (±0.36)	3.37* (±0.33)			CC
Moore et al. (1987)	3.52 (±0.42)	3.54 (±0.35)			CC
Rotstein et al. (1986)			54.2 (±3.67)	58.6* (±3.85)	IR
Sharp et al. (1986)			52.8 (±0.08)	57.1* (±2.13)	IC
Bhambhani and Singh (1985b)	3.11	3.49*			CC
Bhambhani and Singh (1985b)	3.00	3.34*			CC
Bhambhani and Singh (1985b)	3.35	3.76*			IC
Poole and Gaesser (1985)			30.5 (±2.70)	34.9* (±2.11)	CC
Poole and Gaesser (1985)			32.1 (±1.85)	38.6* (±1.66)	CC
Poole and Gaesser (1985)			37.6 (±2.01)	43.3* (±1.61)	IC
Gaesser et al. (1984)	3.69 (±0.17)	4.06* (±0.18)			CC
Smith and O'Donnell (1984)			51.3 (±2.20)	58.2 (±2.90)	CR

CC - continuous/cyle ergometer; CT - continuous/treadmill;
CR - continuous/running or walking; IC - interval/cycle;
IT - interval/treadmill; IR - interval/running or walking
*significant different from pretest

Table 30 - (Continued)

STUDY	PRE VO_2 (l/min)	POST VO_2 (l/min)	PRE VO_2 (ml/kg/min)	POST VO_2 (ml/kg/min)	TYPE
Gaesser and Rich (1984)	2.99 (±0.21)	3.47* (±0.11)	43.3 (±2.4)	50.1* (±1.5)	CC
Gaesser and Rich (1984)	2.71 (±0.11)	3.05* (±0.10)	37.7 (±1.6)	42.5* (±1.4)	CC
Thomas et al. (1984)	4.10 (±0.60)	4.30 (±0.60)	53.8 (±7.00)	55.8 (±4.00)	CR
Thomas et al. (1984)	3.60 (±0.50)	3.90 (±0.60)	51.7 (±4.40)	56.1 (±4.50)	CR
Thomas et al. (1984)	3.90 (±0.40)	4.20 (±0.30)	51.7 (±4.40)	56.8 (±3.00)	IR
Denis et al. (1984)	3.49 (±0.40)	3.72* (±0.40)	48.5 (±3.20)	52.2* (±3.20)	CC
Denis et al. (1984)	3.57 (±0.38)	4.15* (±0.35)	49.8 (±52.2)	58.8* (±3.60)	CC
Golden and Vaccaro (1984)			44.8 (±6.70)	47.3 (±5.30)	CC
Golden and Vaccaro (1984)			42.9 (±8.10)	43.6 (±5.40)	CC
Ready and Quinney (1982)	3.46 (±0.70)	4.73* (±0.70)	45.7 (±8.40)	64.2* (±9.50)	CC
Denis et al. (1982)	3.40 (±0.43)	3.62 (±0.37)			CC
Yoshida et al. (1982)	2.72 (±0.14)	3.10* (±0.18)	43.7 (±1.80)	50.0* (±2.3)	CC
Sjodin et al. (1982)	4.54 (±0.39)	4.64 (±0.29)	68.7 (±2.60)	69.9 (±3.80)	CT

CC - continuous/cycle ergometer; CT - continuous/treadmill;
CR - continuous/running or walking; IC - interval/cycle;
IT - interval/treadmill; IR - interval/running or walking
*significant different from pretest

Table 30 - (Continued)

STUDY	PRE VO_2 (l/min)	POST VO_2 (l/min)	PRE VO_2 (ml/kg/min)	POST VO_2 (ml/kg/min)	TYPE
Smith and Wenger (1981)			51.5 (±1.30)	52.0 (±1.20)	CC
Smith and Wenger (1981)			49.4 (±1.50)	56.9* (±1.30)	CC
Smith and Wenger (1981)			48.9 (±1.8)	49.9 (±1.70)	IC
Smith and Wenger (1981)			50.8 (±1.90)	52.3 (±1.90)	IC
Hickson et al. (1981)	3.12 (±0.21)	3.85* (±0.20)			IC CC
Wilmore et al. (1980)	3.12	3.45*	39.2	44.5*	CR
Wilmore et al. (1980)	3.09	3.56*	37.2	43.1*	CC
Gettman et al. (1979)	3.43 (±0.36)	3.78* (±0.28)	42.5 (±4.00)	47.2* (±2.10)	CR
Cunningham et al. (1979)	1.90 (±0.11)	2.29* (±0.12)	36.8 (±1.80)	44.7* (±2.10)	CC
Cunningham et al. (1979)	2.03 (±0.07)	2.50* (±0.12)	36.6 (±0.80)	44.6* (1.60)	IC
Davis et al. (1979)	2.77 (±0.22)	3.47* (±0.20)	31.1 (±2.40)	40.0* (±2.30)	CC
Dolgener and Brooks (1978)	2.60 (±0.19)	2.93* (±0.15)	35.5 (±2.44)	40.8 (±2.63)	CR
Dolgener and Brooks (1978)	2.72 (±0.17)	2.99 (±0.13)	39.3 (±1.38)	43.6 (±2.21)	IR

CC - continuous/cyle ergometer; CT - continuous/treadmill;
CR - continuous/running or walking; IC - interval/cycle;
IT - interval/treadmill; IR - interval/running or walking
*significant different from pretest

Table 30 - (Continued)

STUDY	PRE VO_2 (l/min)	POST VO_2 (l/min)	PRE VO_2 (ml/kg/min)	POST VO_2 (ml/kg/min)	TYPE
Eddy et al. (1977)	2.78 (±0.34)	3.01* (±0.39)			CC
Eddy et al. (1977)	2.66 (±3.90)	2.87* (±0.33)			IC
Fox et al. (1977)			52.7 (±4.50)	55.1* (±5.10)	IT
Fox et al. (1977)			51.5 (±4.60)	55.6* (±4.7)	IT
Pollock et al. (1976)	2.47 (±0.35)	2.90* (±0.40)	31.0	36.8*	CR
Getchell and Moore (1975)	2.78 (±0.13)	3.42[8] (±0.15)			CR
Davies and Sargeant (1975)	3.06 (±0.52)	3.20 (±0.44)			CC
Fox et al. (1975)	3.19 (±0.44)	3.53* (±0.49)	43.5 (±4.7)	48.0* (±4.5)	IR
Fox et al. (1975)	3.16 (±0.45)	3.45* (±0.46)	44.2 (±4.9)	48.7* (±5.5)	IR
Fox et al. (1975)	3.06 (±0.17)	3.45* (±0.23)	43.2 (±4.80)	49.2* (±4.10)	IR
Fox et al. (1975)	3.16 (±0.61)	3.58* (±0.50)	41.9 (±4.30)	47.7* (±2.7)	IR
Pollock et al. (1975)	2.74 (±0.36)	3.00* (±0.42)	32.6 (±4.02)	36.1* (±4.70)	CR
Pollock et al. (1975)	2.74 (±0.18)	3.04* (±0.24)	32.4 (±3.12)	36.5* (±2.55)	CR

CC - continuous/cyle ergometer; CT - continuous/treadmill; CR - continuous/running or walking; IC - interval/cycle; IT - interval/treadmill; IR - interval/running or walking

*significant different from pretest

Table 30 - (Continued)

STUDY	PRE VO_2 (l/min)	POST VO_2 (l/min)	PRE VO_2 (ml/kg/min)	POST VO_2 (ml/kg/min)	TYPE
Pollock et al. (1975)	2.72 (±0.19)	3.34* (±0.39)	33.1 (±4.26)	40.9* (±4.79)	CC
Girandola and Katch (1973)	3.49 (±0.58)	3.72* (±0.50)	45.9 (±8.35)	49.0* (±7.49)	O
Knuttgen et al. (1973)	3.07 (±0.10)	3.56* (±0.10)	45.8 (±1.20)	52.6* (±1.00)	IR
Knuttgen et al. (1973)	2.86 (±0.14)	3.59* (±0.14)	43.1 (±1.90)	53.4* (±1.80)	IR
Knuttgen et al. (1973)	3.18 (±0.17)	3.90* (±0.15)	46.4 (±2.30)	57.0* (±2.40)	IR
Pollock et al. (1972)	2.84 (±0.28)	3.36* (±0.41)	36.0 (±3.00)	40.1* (±3.50)	CR
Pollock et al. (1972)	3.11 (±0.38)	3.52* (±0.41)	38.5 (±42.8)	44.0* (±3.90)	CR
Fox et al. (1972)	3.20 (±0.30)	3.49* (±0.21)	45.4 (±5.80)	49.0* (±3.30)	IR
Fox et al. (1972)	3.23 (±0.52)	3.39* (±0.51)	45.8 (±6.00)	48.2 (±7.40)	IR
Fox et al. (1972)	3.26 (±0.38)	3.50* (±0.40)	44.4 (±5.30)	48.4* (±5.90)	IR
Davies and Knibbs (1971)			47.0 (±4.80)	46.7 (±5.40)	CC
Davies and Knibbs (1971)			50.8 (±2.50)	52.5 (±3.60)	CC
Pollock et al. (1971)	2.30 (±0.40)	2.90* (±0.40)			CR

CC - continuous/cyle ergometer; CT - continuous/treadmill;
CR - continuous/running or walking; IC - interval/cycle;
IT - interval/treadmill; IR - interval/running or walking; O - other
*significant different from pretest

Table 31 - Terms and operational definitions found in the literature, used in the discussion.

AUTHORS	TERMINOLOGY	OPERATIONAL DEFINITION
Wasserman and McIlroy (1964)	Anaerobic Threshold (AT)	The exercise intensity at which the level of lactic acid in the blood increases significantly above the resting values
Reinhard et al. (1979)	Anaerobic Threshold (AT)	The exercise intensity at which the V_E/VO_2 reached minimum
Reinhard et al. (1979)	Threshold of Decompensated Metabolic Acidosis (TDMA)	The exercise intensity at which the V_E/VCO_2 reached a minimum
Skinner and McLellan (1980)	Aerobic Threshold (AeT)	The exercise intensity at which where blood lactate begins to rise and where V_E and VCO_2 show an initial disproportionate rise
Skinner and McLellan (1980)	Anaerobic Threshold (AnT)	The exercise intensity where a secon "break-away" in V_E occurs and is usually associated with the onset of a rapid rise in blood lactate

*Term used in the present study

**Definition used in the present study

Table 31 - (continued)

AUTHORS	TERMINOLOGY	OPERATIONAL DEFINITION
Sjodin and Jacobs (1981)	Onset of Blood Lactate Accumulation (OBLA)	The exercise intensity corresponding to a blood lactate concentration of 4 $mmol.l^{-1}$
Bhambhani and Singh (1985)	Ventilatory Threshold One (VT1)	The exercise intensity at which the V_E/VO_2 and F_ECO_2 reach a minimum
Bhambhani and Singh (1985)	*Ventilatory Threshold Two (VT2)	**The exercise intensity at which the V_E/VCO_2 reaches a minimum and F_ECO_2 reaches a maximum

*Term used in the present study
**Definition used in the present study

Table 32 - Studies published in the last two decades on the effects of training on oxygen consumption at the anaerobic threshold, or lactate threshold or ventilatory threshold in male subjects.

STUDY	PRE VO_2 (l/min)	POST VO_2 (l/min)	PRE VO_2 (% of max)	POST VO_2 (% of max)	TYPE
Denis et al. *(1988)*	1.90 (±0.30)	2.40* (±0.40)	60.0 (±3.0)	70.0* (±6.0)	CC
Denis et al. *(1988)*	2.20 (±0.30)	2.80* (±0.30)	74.0 (±4.0)	80.0* (±5.0)	CC
Hill et al. *(1987)*	1.64 (±0.08)	2.05* (±0.09)	58.6 (±1.9)	65.5* (±1.7)	IC CC CR
Poole and Gaesser *(1985)*	1.19 (±0.07)	1.41* (±0.06)	39.8 (±2.8)	41.1 (±3.0)	CC
Poole and Gaesser *(1985)*	1.42 (±0.15)	1.82* (±0.11)	43.7 (±2.5)	47.2 (±1.8)	CC
Poole and Gaesser *(1985)*	1.53 (±0.14)	2.23* (±0.15)	40.9 (±4.4)	51.3* (±3.9)	IC
Smith and O'Donnell *(1984)*	2.27 (±0.17)	3.00* -	62.3 -	73.0* -	CR
Golden and Vaccaro *(1984)*	2.20 (±0.29)	2.23 (±0.43)	65.8 (±7.1)	63.2 (±10.5)	CC
Golden and Vaccaro *(1984)*	2.08 (±0.27)	2.11 (±0.21)	66.0 (±4.1)	66.2 (±7.5)	CC
Gaesser and Poole *(1984)*	1.68 (±0.11)	1.77 (±0.12)	45.5 (±2.0)	45.1 (±2.6)	CC
Bhambhani et al. *(1983)*	2.42	2.73*	74.9	75.4	CC
Bhambhani et al. *(1983)*	1.90	2.87*	60.4	70.4	CC

CC - continuous/cyle ergometer; CT - continuous/treadmill;
CR - continuous/running or walking; IC - interval/cycle;
IT - interval/treadmill; IR - interval/running or walking
* *significant different from pretest*

Table 32 - (continued).

STUDY	PRE VO_2 (l/min)	POST VO_2 (l/min)	PRE VO_2 (% of max)	POST VO_2 (% of max)	TYPE
Bhambhani et al. (1983)	2.31	2.87*	69.5	73.7	IC
Sjodin et al. (1982)			85.3 (±3.2)	86.6 (±3.8)	CT
Denis et al. (1982)			74.0 (±4.0)	81.0 (±4.0)	CC
Ready and Quinney (1982)	2.13 (±0.37)	3.63* (±0.46)	64.9 (±14.4)	77.5* (±11.0)	CC
Yoshida et al. (1982)	1.00 (±0.03)	1.37* (±0.15)	37.4 (±2.2)	44.1 (±3.6)	CC
Davis et al. (1979)	1.36 (±0.10)	1.96* (±0.10)	49.4 (±2.60)	57.0* (±2.10)	CC

CC - continuous/cyle ergometer; CT - continuous/treadmill;
CR - continuous/running or walking; IC - interval/cycle;
IT - interval/treadmill; IR - interval/running or walking
* significant different from pretest

Table 33 - Relationship between changes in VO_2 max and VO_2 at the ventilatory threshold two.

GROUP	CHANGE FROM	r	r^2
VTG (n=8)	TEST 2-1	0.397	0.158
	3-2	0.189	0.036
	4-3	0.442	0.195
	5-4	0.506	0.256
	5-1	0.059	0.004
BVTG (n=10)	TEST 2-1	0.306	0.094
	3-2	0.740[a]	0.548
	4-3	0.297	0.088
	5-4	0.548	0.300
	5-1	0.314	0.099
ITG (n=7)	TEST 2-1	0.212	0.045
	3-2	-0.600	0.360
	4-3	0.406	0.164
	5-4	0.312	0.098
	5-1	-0.499	0.249
ALL GROUPS (n=25)	TEST 2-1	0.397[b]	0.158
	3-2	0.223	0.050
	4-3	0.183	0.034
	5-4	-0.422[b]	0.178
	5-1	0.162	0.026

[a] significant at .05 (critical value = .632)
[b] significant at .05 (critical value = .396)

obs.: TEST 2-1 = VO_2 max from TEST 2 minus VO_2 max from TEST1 versus VO_2 at VT2 from TEST 2 minus VO_2 at VT2 from TEST 1

Table 34 - Effects of training at different exercise intensities on skinfold measurements (percent change from pre training). Data from the present study and from Despres et al.,1985.

SKINFOLD	VTG	BVTG	ITG	DESPRES ET AL. 1985
TRICEPS	-3.85	-7.52	-2.85	-11.0
SUBSCAPULA	-0.15	-6.67	+0.13	-12.0
SUPRAILIAC	+7.32	-10.64	+3.20	-18.0
ABDOMEN	+2.20	-11.53	+13.30	-13.0
BICEPS	+9.38	+2.24	+5.17	-9.0
THIGH	+10.80	-2.87	+8.82	-13.0
CALF	+1.39	-4.75	-2.63	-7.0

obs.: data from Despres et al. was measured on left side of the body according to the International Biological Programme, while in the present study measurements were taken on the right side according to the techniques recommended by the International Working Group on Kinathropometric Techniques.

Table 35 - Ratios of subcutaneous fat to total body fat (7SKF/ % body fat) as a result of training at different exercise intensities. Pre, mid, and post training values from the present study, and pre and post training data from Despres et al. 1985.

GROUP	PRE	MID	POST
VTG	4.57 (1.20)	4.78 (0.92)	4.65 (0.81)
BVTG	4.57 (0.80)	4.59 (0.63)	4.66 (0.55)
ITG	4.58 (1.01)	4.64 (1.03)	5.08 (1.16)
CG	5.53 (0.87)		6.50 (1.50)
DESPRES ET AL. 1985	5.30 (0.70)		5.30 (0.80)

obs.: data from Despres et al. was measured on left side of the body according to the International Biological Programme, while in the present study measurements were taken on the right side according to the techniques recommended by the International Working Group on Kinathropometric Techniques.

Table 36 - Ratios of subcutaneous fat corrected for the skin thickness to total body fat ((7SKF - 28 mm) / % body fat) as a result of training at different exercise intensities. Pre, mid, and post training values from the present study, and pre and post training data from Despres et al. 1985.

GROUP	PRE	MID	POST
VTG	3.21 (1.38)	3.35 (1.17)	3.25 (1.10)
BVTG	3.48 (0.54)	3.47 (0.59)	3.45 (0.58)
ITG	3.20 (1.09)	3.24 (1.08)	3.59 (1.27)
CG	3.17 (1.18)		3.63 (1.06)
DESPRES ET AL. 1985	3.20 (1.50)		2.90 (1.30)

obs.: data from Despres et al. was measured on left side of the body according to the International Biological Programme, while in the present study measurements were taken on the right side according to the techniques recommended by the International Working Group on Kinathropometric Techniques.

Correction of skinfolds is based on the assumption that the thickness of a double layer of skin equals 4 mm (Allen et al.,1956). As seven skinfolds were measured, the correction was 28 mm.

Table 37 - Relationship between changes in FFA concentration during training at different exercise intensities and changes in body density.

GROUP	TIME	r	r^2
VTG (n=8)	BEG END	-0.378 -0.149	0.143 0.022
BVTG (n=10)	BEG END	-0.224 -0.525	0.050 0.276
ITG (n=7)	BEG END	-0.278 0.185	0.077 0.034
ALL GROUPS (n=25)	BEG END	0.107 0.103	0.011 0.011

obs.: BEG - FFA concentration measured in the first week of training
END - FFA concentration measured in the last week of training

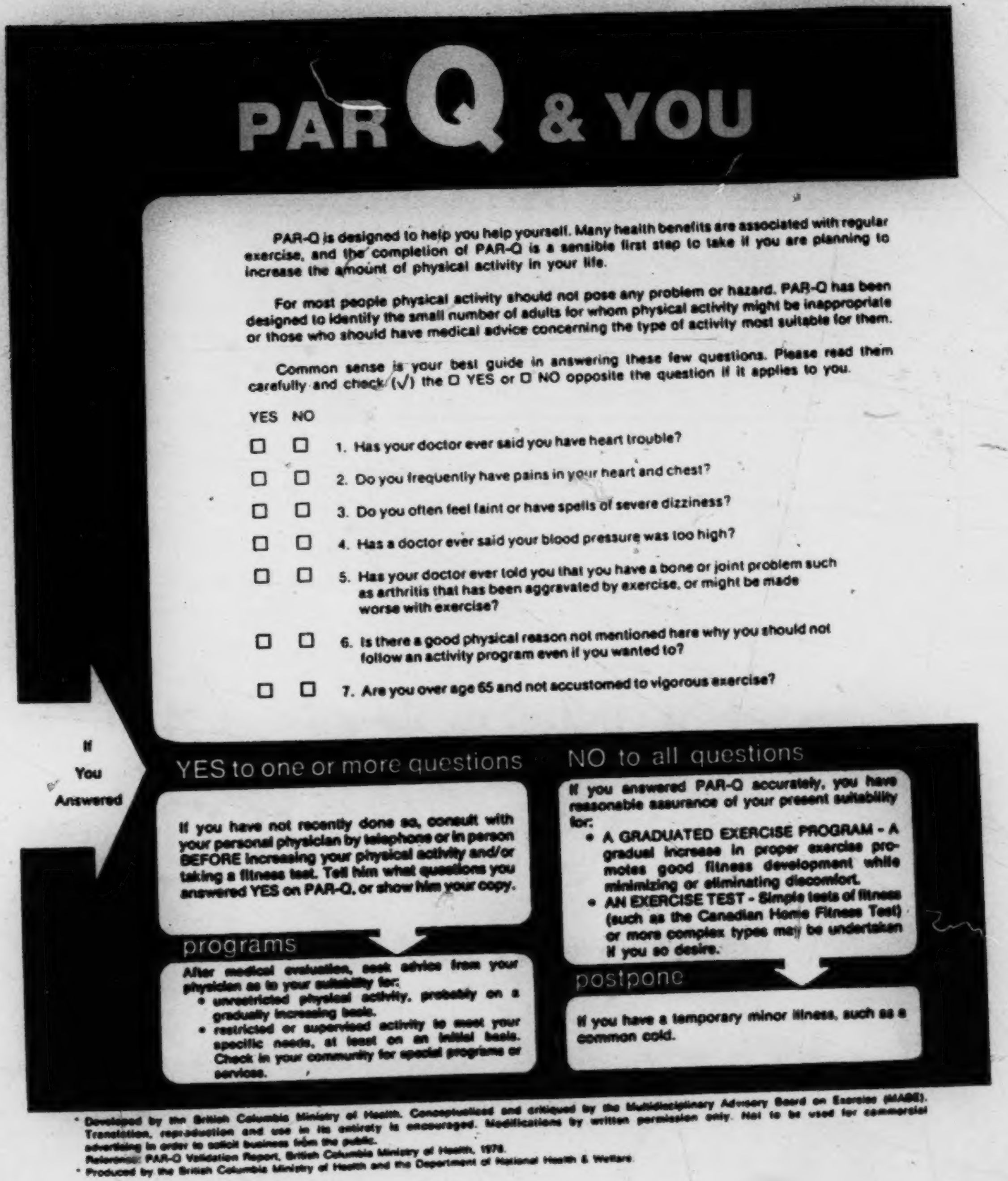
Table 38 - Relationship between changes in FFA concentration during training at different exercise intensities and changes in the sum of seven skinfolds.

GROUP	TIME	r	r^2
VTG (n=8)	BEG END	0.564 -0.374	0.319 0.140
BVTG (n=10)	BEG END	0.788 0.276	0.621 0.076
ITG (n=7)	BEG END	-0.218 -0.353	0.048 0.124
ALL GROUPS (n=25)	BEG END	-0.069 -0.374	0.005 0.140

obs.: BEG - FFA concentration measured in the first week of training

END - FFA concentration measured in the last week of training

APPENDIX E



PAR Q & YOU

PAR-Q is designed to help you help yourself. Many health benefits are associated with regular exercise, and the completion of PAR-Q is a sensible first step to take if you are planning to increase the amount of physical activity in your life.

For most people physical activity should not pose any problem or hazard. PAR-Q has been designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.

Common sense is your best guide in answering these few questions. Please read them carefully and check (√) the ☐ YES or ☐ NO opposite the question if it applies to you.

YES	NO	
☐	☐	1. Has your doctor ever said you have heart trouble?
☐	☐	2. Do you frequently have pains in your heart and chest?
☐	☐	3. Do you often feel faint or have spells of severe dizziness?
☐	☐	4. Has a doctor ever said your blood pressure was too high?
☐	☐	5. Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise?
☐	☐	6. Is there a good physical reason not mentioned here why you should not follow an activity program even if you wanted to?
☐	☐	7. Are you over age 65 and not accustomed to vigorous exercise?

If You Answered

YES to one or more questions

If you have not recently done so, consult with your personal physician by telephone or in person BEFORE increasing your physical activity and/or taking a fitness test. Tell him what questions you answered YES on PAR-Q, or show him your copy.

programs

After medical evaluation, seek advice from your physician as to your suitability for:

- unrestricted physical activity, probably on a gradually increasing basis.
- restricted or supervised activity to meet your specific needs, at least on an initial basis. Check in your community for special programs or services.

NO to all questions

If you answered PAR-Q accurately, you have reasonable assurance of your present suitability for:

- A GRADUATED EXERCISE PROGRAM - A gradual increase in proper exercise promotes good fitness development while minimizing or eliminating discomfort.
- AN EXERCISE TEST - Simple tests of fitness (such as the Canadian Home Fitness Test) or more complex types may be undertaken if you so desire.

postpone

If you have a temporary minor illness, such as a common cold.

* Developed by the British Columbia Ministry of Health. Conceptualized and critiqued by the Multidisciplinary Advisory Board on Exercise (MABE). Translation, reproduction and use in its entirety is encouraged. Modifications by written permission only. Not to be used for commercial advertising in order to solicit business from the public.
Reference: PAR-Q Validation Report, British Columbia Ministry of Health, 1978.
* Produced by the British Columbia Ministry of Health and the Department of National Health & Welfare.

APPENDIX F

CONSENT FORM

I, ____ hereby agree to volunteer in a study titled, "Effects of Continuous and Intermittent Training on Body Composition and Selected Physiological Parameters".

I understand that I will be required to:

1. Perform a minimum of two (for subjects in the Control Group) or a maximum of six (for subjects in the Exercising Group) graded exercise tests on a bicycle ergometer designed to determine my Maximum Exercise Capacity.

2. Undergo a minimum of two (for subjects in the Control Group) or a maximum of six (for subjects in the Exercising Group) tests designed to determine my percent body fat by the hydrostatic method.

3. Undergo a minimum of two (for subjects in the Control Group) or a maximum of six (for subjects in the Exercising Group) anthropometric protocols in order to assess the amount of fat in different sites of the body.

4. Train on a bicycle ergometer three times a week for a period of 12 weeks, at either a submaximal or maximal work capacity (for subjects in the Exercising Group). Each training session will last a maximum of 30 minutes. During two of these training sessions, a 5 ml blood sample will be withdraw from my cubital vein prior to the beginning of the training, after five minutes of exercise and after fifteen minutes of exercise. The samples will be analysed for lactate and FFA concentration.

It is my understanding that:

1. All training and testing sessions will be supervised by qualified and experienced technicians, which are familiar with the guidelines for terminating a graded maximal exercise test.

2. Blood samples will be withdrawn by an experienced lab technician.

3. If at any time during the tests or training I experience unusual discomfort, I will be allowed to discontinue the activity. I will also be allowed to opt out of the study at any time during its course without any obligation of offering an explanation.

I have completed the Physical Activity Readiness Questionnaire (PAR-Q) and the information provided is accurate to the best of my knowledge.

By agreeing to participate in such a study, I waive any legal recourse against the University of Alberta or its representatives, from any and all claims resulting from the study.

Subject: ______________________________

Witness: ______________________________

Investigator: __________________________
Paulo Sergio Chagas Gomes

Date: January ____, 1987

APPENDIX G

THE DENSITY OF WATER AT VARIOUS TEMPERATURES

TEMPERATURE C°	DENSITY
20	.9982
21	.9980
22	.9978
23	.9976
24	.9973
25	.9971
26	.9968
27	.9965
28	.9963
29	.9960
30	.9957
31	.9954
32	.9951
33	.9947
34	.9944
35	.9941
36	.9937
37	.9934
38	.9930
39	.9926
40	.9922

APPENDIX H

CALCULATIONS FOR UNDERWATER WEIGHING

MEASUREMENTS:

1. Weight in air ....(lbs)*
2. Vital capacity ....(liters)* x 61.02 = ...cu.in.
3. Residual volume ....cu.in.
   (30% - males, 25% - females of the V.C. in cubic inches)
4. Volume of the gastro-intestinal track = ...7.01........cu.in.
5. Weight in water =
   [(chart reading* x belt wt)/75] - belt wt = ...

CALCULATIONS:

6. Total Body Air =

V. C. ....(cu. in.) (from #2)
+R.V. ....(cu. in.) (from #3)
+G.I. ....7.01.......(cu. in.)

= .... x 0.0362 = ...(lbs)

7. True weight in water = wt in water + total body air
   #5.............. + #6................ = ...lbs
8. Body volume = wt in air - true wt in water
   #1 .... - #7 .... = ...lbs
9. Body density = [wt in air/ body volume] x density of water*
   [#1 .... / #8.....................] x .... = ...
10. Fat % = [(4.570 / body density) - 4.142] x 100 = ...%
11. Lbs of fat = [% fat .... x wt in air ....] / 100 =
    ....lbs
12. Lean body weight (LBW) = wt in air - lbs of fat
    #1 ....- #11 .... = ...LBW

APPENDIX I

Directions For Daily Menu

The purpose of this study is to discover everthing you consume during a three day period. It is important to record all foods and beverages – from a full course family dinner at home to a quick cup of coffee at work. Before you begin to record in your diary, however, please read the following directions and examine closely the sample day:

There is a section for every day.

The day is broken into 6 consumption periods:

Morning Meal
Midmorning Snack

Midday Meal
Afternoon Snack

Evening Meal
Evening Snack

Foods and beverages consumed away from home – at work, at a restaurant, or when visiting friends – are just as important as those eaten at home. Therefore, it is important that your record your entries as soon after eating as possible. The following entries should be included in your recording:

1. **Menu Item Column:** Enter in this column all foods, beverages, etc. consumed during the meal or snack. If your family eats two kinds of cereals or has several different types of sandwiches for example, please record the correct type.

   Enter in the same block as the menu item all toppings or additives used on the menu item at the time of eating (syrups, gravies, butter, milk, sugar, etc.). Please be specific in your entries – maple syrup, 2% lowfat milk, grape jelly, etc.

2. **Unit of Measure Column:** For every menu item and every topping or additive, enter in this column either the word "number", "cup", "ounce", "teaspoon", or "tablespoon", Not only the menu item, but the topping or additive as well, must have its own unit of measure.

3. **Number of Units Column:** In this area, record the number of units consumed. Include the amount of the menu item and the amount of toppings or additives consumed. An estimate of the unit is satisfactory. Actual measuring is unnecessary unless the exact weight, eg. meat, is known.

4. **Description Column:** For ever menu item please include in this column:

   - the brand (if known)
   - the type and flavour (if applicable) i.e. homemade, strawberry waffles
   - the method of cooking (if applicable) i.e. scrambled, baked, fried

   It is not necessary to describe the toppings or additives, only the menu item.

5. **"Where Eaten" Category:** Items consumed away from home are just as important as those items consumed at home. All consumption should be recorded. It is also important, at the end of each meal, to check where that meal was consumed.

   For example at the morning meal, one of the three categories below must be checked:
   Eaten at home
   Eaten away from home
   Did not eat

6. **Daily Check:** After you have finished your recording for the day, go back over your entries and make sure that for every entry (every menu item, and topping or additive), there is an appropriate unit of measure and the corresponding numbers are given. Also check to see that at the end of each meal, the appropriate category is checked.

What you eat and drink everyday is important and your entry should be as accurate as possible.

Thank you for your participation and co-operation in helping to produce a detailed quality study. Please examine carefully the sample day before beginning.

SAMPLE

		MENU ITEM	UNIT OF MEAS.		DESCRIPTION OF MENU ITEM		
		Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating	Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"	No. of Units	Brand	Type of Flavour	Method of Cooking
MORNING MEAL	Menu Item	eggs	number	3	Dorland		scrambled
	Toppings or Additives	ketchup	tablespoon	2			
	Menu Item	sausage links	number	2	Schneider	sausage	fried
	Toppings or Additives						
	Menu Item	whole milk	cup	[illegible]	Silverwood		
	Toppings or Additives	choc mix	table[illegible]	2			
	Menu Item	corn flakes	cup	2	Kellogg	cornflakes	
	Toppings or Additives	whole milk sugar	cup tsp.	1 1			
	Menu Item	banana	no.	1			
	Toppings or Additives						
	Menu Item	multi vitamin	number	1	One-A-Day		
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home		X			
		Eaten Away From Your Home					
		Did Not Eat					

Sample Day

MENU ITEM			UNIT OF MEAS.	No. of Units	DESCRIPTION OF MENU ITEM		
Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating			Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"		Brand	Type of Flavour	Method of Cooking
MORNING MEAL	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day One

MENU ITEM			UNIT OF MEAS.	No. of Units	DESCRIPTION OF MENU ITEM		
Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating			Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"		Brand	Type of Flavour	Method of Cooking
MIDMORNING SNACK	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day One

MENU ITEM			UNIT OF MEAS.	No. of Units	DESCRIPTION OF MENU ITEM		
Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating			Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"		Brand	Type of Flavour	Method of Cooking
MIDDAY MEAL	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day One

MENU ITEM			UNIT OF MEAS.	No. of Units	DESCRIPTION OF MENU ITEM		
Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating			Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"		Brand	Type of Flavour	Method of Cooking
AFTERNOON SNACK	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day One

MENU ITEM			UNIT OF MEAS.	No. of Units	DESCRIPTION OF MENU ITEM		
Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating			Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"		Brand	Type of Flavour	Method of Cooking
EVENING MEAL	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day One

MENU ITEM			UNIT OF MEAS.	No. of Units	DESCRIPTION OF MENU ITEM		
Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating			Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"		Brand	Type of Flavour	Method of Cooking
EVENING SNACK	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day One

MENU ITEM			UNIT OF MEAS.		DESCRIPTION OF MENU ITEM		
Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating			Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"	No. of Units	Brand	Type of Flavour	Method of Cooking
MORNING MEAL	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day Two

MENU ITEM			UNIT OF MEAS.		DESCRIPTION OF MENU ITEM		
Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating			Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"	No. of Units	Brand	Type of Flavour	Method of Cooking
MIDMORNING SNACK	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day Two

		MENU ITEM	UNIT OF MEAS.	No. of Units	DESCRIPTION OF MENU ITEM		
		Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating	Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"		Brand	Type of Flavour	Method of Cooking
MIDDAY MEAL	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day Two

		MENU ITEM	UNIT OF MEAS.	No. of Units	DESCRIPTION OF MENU ITEM		
		Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating	Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"		Brand	Type of Flavour	Method of Cooking
AFTERNOON SNACK	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day Two

	MENU ITEM		UNIT OF MEAS.	No. of Units	DESCRIPTION OF MENU ITEM		
	Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating		Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"		Brand	Type of Flavour	Method of Cooking
EVENING MEAL	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day Two

	MENU ITEM		UNIT OF MEAS.	No. of Units	DESCRIPTION OF MENU ITEM		
	Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating		Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"		Brand	Type of Flavour	Method of Cooking
EVENING SNACK	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day Two

MENU ITEM			UNIT OF MEAS.	No. of Units	DESCRIPTION OF MENU ITEM		
Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating			Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"		Brand	Type of Flavour	Method of Cooking
MORNING MEAL	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day Three

MENU ITEM			UNIT OF MEAS.	No. of Units	DESCRIPTION OF MENU ITEM		
Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating			Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"		Brand	Type of Flavour	Method of Cooking
MIDMORNING SNACK	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away from Home					
		Did Not Eat					

Day Three

MENU ITEM			UNIT OF MEAS.	No. of Units	DESCRIPTION OF MENU ITEM		
Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating			Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"		Brand	Type of Flavour	Method of Cooking
MIDDAY MEAL	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day Three

MENU ITEM			UNIT OF MEAS.	No. of Units	DESCRIPTION OF MENU ITEM		
Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating			Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"		Brand	Type of Flavour	Method of Cooking
AFTERNOON SNACK	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day Three

MENU ITEM			UNIT OF MEAS.		DESCRIPTION OF MENU ITEM		
Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating			Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"	No. of Units	Brand	Type of Flavour	Method of Cooking
EVENING MEAL	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day Three

MENU ITEM			UNIT OF MEAS.		DESCRIPTION OF MENU ITEM		
Enter all foods, beverages, etc. consumed as menu items. For every menu item, include any toppings or additives added to the menu item at the time of eating			Enter the Word "cup" "ounce" "number" "teaspoon" "tablespoon"	No. of Units	Brand	Type of Flavour	Method of Cooking
EVENING SNACK	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Menu Item						
	Toppings or Additives						
	Mark (X) One Category	Eaten at Your Home					
		Eaten Away From Your Home					
		Did Not Eat					

Day Three

APPENDIX J

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        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: AGE
TYPE       PART OF MODEL                  SSH        SSE        MSH         MSE      F-RATIO      DFH       DFE     PROB

UNIV  GRAND MEAN                        43363.64    2109.45  43363.64      63.92     678.37       1.0      33.0  .139E-22
UNIV  GROUP                           *   765.79    2109.45    255.26      63.92       3.99       3.0      33.0  0.01567
UNIV  GRAND MEAN                        43363.64    2109.45  43363.64      63.92     678.37       1.0      33.0  .139E-22
UNIV  GROUP                               765.79    2109.45    255.26      63.92       3.99       3.0      33.0  0.01567
UNIV  CASES(GROUP)                    *  2109.45       ****     63.92       ****       ****      33.0      ****     ****
ERROR TERM: CASES(GROUP)

                       AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                       TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.


        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: HT
TYPE       PART OF MODEL                  SSH        SSE        MSH         MSE      F-RATIO      DFH       DFE     PROB

UNIV  GRAND MEAN                       0.10476E7    1304.12 0.10476E7      39.52   26510.47       1.0      33.0  .158E-48
UNIV  GROUP                           *    69.42    1304.12     23.14      39.52       0.59       3.0      33.0  0.62877
UNIV  GRAND MEAN                       0.10476E7    1304.12 0.10476E7      39.52   26510.47       1.0      33.0  .158E-48
UNIV  GROUP                                69.42    1304.12     23.14      39.52       0.59       3.0      33.0  0.62877
UNIV  CASES(GROUP)                    *  1304.12       ****     39.52       ****       ****      33.0      ****     ****
ERROR TERM: CASES(GROUP)

                       AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                       TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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           UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: WT
                                                  SSH        SSE       MSH        MSE    F-RATIO     DFH      DFE    PROB
TYPE      PART OF MODEL
                                            224368.18    2694.98 224368.18      81.67    2747.38     1.0     33.0 .234E-32
UNIV  GRAND MEAN                         *     120.49    2694.98     40.16      81.67       0.49     3.0     33.0 0.69040
UNIV  GROUP                                 224368.18    2694.98 224368.18      81.67    2747.38     1.0     33.0 .234E-32
UNIV  GRAND MEAN                               120.49    2694.98     40.16      81.67       0.49     3.0     33.0 0.69040
UNIV  GROUP                              *    2694.98       ****     81.67       ****       ****    33.0     ****     ****
UNIV  CASES(GROUP)
ERROR TERM: CASES(GROUP)

                             AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                             TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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           UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: DENS
                                                  SSH        SSE       MSH        MSE    F-RATIO     DFH      DFE    PROB
TYPE      PART OF MODEL
                                                36.75 0.5400E-2      36.75 0.1636E-3 224572.67     1.0     33.0  0.0
UNIV  GRAND MEAN                          *0.3640E-2 0.5400E-2 0.1213E-2 0.1636E-3       7.42     3.0     33.0  0.00063
UNIV  GROUP                                     36.75 0.5400E-2      36.75 0.1636E-3 224572.67     1.0     33.0  0.0
UNIV  GRAND MEAN                           0.3640E-2 0.5400E-2 0.1213E-2 0.1636E-3       7.42     3.0     33.0  0.00063
UNIV  GROUP                               *0.5400E-2       **** 0.1636E-3       ****       ****    33.0     ****     ****
UNIV  CASES(GROUP)
ERROR TERM: CASES(GROUP)

                             AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                             TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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         UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: PERCFAT
TYPE       PART OF MODEL                     SSH        SSE        MSH       MSE     F-RATIO     DFH     DFE    PROB

                                          13726.36     949.10  13726.36     28.76    477.26      1.0    33.0 .338E-20
UNIV  GRAND MEAN                        *   616.12     949.10    205.37     28.76      7.14      3.0    33.0  0.00080
UNIV  GROUP                               13726.36     949.10  13726.36     28.76    477.26      1.0    33.0 .338E-20
UNIV  GRAND MEAN                            616.12     949.10    205.37     28.76      7.14      3.0    33.0  0.00080
UNIV  GROUP                             *   949.10       ****     28.76      ****      ****     33.0    ****    ****
UNIV  CASES(GROUP)
ERROR TERM: CASES(GROUP)

                   AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                   TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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         UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: FATKG
TYPE       PART OF MODEL                     SSH        SSE        MSH       MSE     F-RATIO     DFH     DFE    PROB

                                           9607.09    1193.15   9607.09     36.16    265.71      1.0    33.0 .238E-16
UNIV  GRAND MEAN                        *   521.90    1193.15    173.97     36.16      4.81      3.0    33.0  0.00689
UNIV  GROUP                                9607.09    1193.15   9607.09     36.16    265.71      1.0    33.0 .238E-16
UNIV  GRAND MEAN                            521.90    1193.15    173.97     36.16      4.81      3.0    33.0  0.00689
UNIV  GROUP                             *  1193.15       ****     36.16      ****      ****     33.0    ****    ****
UNIV  CASES(GROUP)
ERROR TERM: CASES(GROUP)

                   AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                   TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: LBM

TYPE       PART OF MODEL                        SSH          SSE        MSH         MSE      F-RATIO     DFH      DFE    PROB

UNIV  GRAND MEAN                             141119.98    1251.59 141119.98     37.93    3720.83      1.0     33.0 .165E-34
UNIV  GROUP                                *    142.58    1251.59     47.53     37.93       1.25      3.0     33.0 0.30640
UNIV  GRAND MEAN                             141119.98    1251.59 141119.98     37.93    3720.83      1.0     33.0 .165E-34
UNIV  GROUP                                     142.58    1251.59     47.53     37.93       1.25      3.0     33.0 0.30640
UNIV  CASES(GROUP)                         *   1251.59       ****     37.93      ****       ****     33.0     ****    ****
ERROR TERM: CASES(GROUP)

                     AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                     TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: SUMSKF
                                                SSH          SSE        MSH         MSE      F-RATIO     DFH      DFE    PROB
TYPE       PART OF MODEL
                                             324432.44   34663.10 324432.44   1050.40     308.87      1.0     33.0 .255E-17
UNIV  GRAND MEAN                           *   8744.82   34663.10   2914.94   1050.40       2.78      3.0     33.0 0.05672
UNIV  GROUP                                  324432.44   34663.10 324432.44   1050.40     308.87      1.0     33.0 .255E-17
UNIV  GRAND MEAN                               8744.82   34663.10   2914.94   1050.40       2.78      3.0     33.0 0.05672
UNIV  GROUP                                * 34663.10        ****   1050.40      ****       ****     33.0     ****    ****
UNIV  CASES(GROUP)
ERROR TERM: CASES(GROUP)

                     AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                     TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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            UNIQUE           SUMMARY TABLE OF F-RATIOS FOR: VO2L1
                                                  SSH        SSE        MSH        MSE     F-RATIO     DFH      DFE     PROB
TYPE        PART OF MODEL
                                                710.71      17.13     710.71      0.63    1120.34      1.0     27.0 .160E-22
UNIV  GRAND MEAN                                  0.48      17.13       0.16      0.63       0.25      3.0     27.0 0.85997
UNIV  GROUP
ERROR TERM: CASES(GROUP)
                                                  0.63       0.86       0.63      0.03      19.62      1.0     27.0 0.00014
UNIV  TIME                                        0.75       0.86       0.25      0.03       7.80      3.0     27.0 0.00066
UNIV  GROUP*TIME                               * 17.13       0.86       0.63      0.03      19.88     27.0     27.0 .883E-11
UNIV  CASES(GROUP)                             *  0.86       ****       0.03      ****       ****     27.0     ****    ****
UNIV  TIME*CASES(GROUP)
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.



            UNIQUE           SUMMARY TABLE OF F-RATIOS FOR: VO2ML1
                                                  SSH        SSE        MSH        MSE     F-RATIO     DFH      DFE     PROB
TYPE        PART OF MODEL
                                             107688.20    3590.45  107688.20    132.98     809.81      1.0     27.0 .113E-20
UNIV  GRAND MEAN                                212.58    3590.45      70.86    132.98       0.53      3.0     27.0 0.66364
UNIV  GROUP
ERROR TERM: CASES(GROUP)
                                                 92.01     130.17      92.01      4.82      19.09      1.0     27.0 0.00017
UNIV  TIME                                      123.96     130.17      41.32      4.82       8.57      3.0     27.0 0.00037
UNIV  GROUP*TIME                             * 3590.45     130.17     132.98      4.82      27.58     27.0     27.0 .148E-12
UNIV  CASES(GROUP)                           *  130.17       ****       4.82      ****       ****     27.0     ****    ****
UNIV  TIME*CASES(GROUP)
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: WT1

TYPE      PART OF MODEL                    SSH        SSE       MSH        MSE     F-RATIO     DFH      DFE     PROB

UNIV  GRAND MEAN                     403030.35    4368.12 403030.35     161.78    2491.19      1.0     27.0 .391E-27
UNIV  GROUP                             921.34    4368.12    307.11     161.78       1.90      3.0     27.0 0.15372
ERROR TERM: CASES(GROUP)

UNIV  TIME                           0.4772E-4      19.68 0.4772E-4       0.73 0.6547E-4      1.0     27.0 0.99360
UNIV  GROUP*TIME                         11.37      19.68      3.79       0.73       5.20      3.0     27.0 0.00578
UNIV  CASES(GROUP)                   *  4368.12      19.68    161.78       0.73     221.95     27.0     27.0 .193E-24
UNIV  TIME*CASES(GROUP)              *    19.68       ****      0.73       ****       ****     27.0     ****    ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.


        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: VE1

TYPE      PART OF MODEL                    SSH        SSE       MSH        MSE     F-RATIO     DFH      DFE     PROB

UNIV  GRAND MEAN                     0.10798E7   44503.48 0.10798E7    1648.28     655.14      1.0     27.0 .180E-19
UNIV  GROUP                            2084.80   44503.48    694.93    1648.28       0.42      3.0     27.0 0.73900
ERROR TERM: CASES(GROUP)

UNIV  TIME                              216.09    7519.89    216.09     278.51       0.78      1.0     27.0 0.38618
UNIV  GROUP*TIME                       6867.45    7519.89   2289.15     278.51       8.22      3.0     27.0 0.00048
UNIV  CASES(GROUP)                   * 44503.48    7519.89   1648.28     278.51       5.92     27.0     27.0 0.773E-5
UNIV  TIME*CASES(GROUP)              *  7519.89       ****    278.51       ****       ****     27.0     ****    ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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           UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: VC021
TYPE       PART OF MODEL                  SSH        SSE        MSH        MSE     F-RATIO     DFH       DFE    PROB

UNIV   GRAND MEAN                      944.03      21.04     944.03       0.78     1211.65     1.0      27.0 .569E-23
UNIV   GROUP                             0.57      21.04       0.19       0.78        0.25     3.0      27.0 0.86369
ERROR  TERM: CASES(GROUP)

UNIV   TIME                              0.36       2.44       0.36       0.09        4.03     1.0      27.0 0.05485
UNIV   GROUP*TIME                        0.82       2.44       0.27       0.09        3.02     3.0      27.0 0.04680
UNIV   CASES(GROUP)                 *   21.04       2.44       0.78       0.09        8.62    27.0      27.0 0.153E-6
UNIV   TIME*CASES(GROUP)            *    2.44       ****       0.09       ****        ****    27.0      ****    ****
ERROR  TERM: TIME*CASES(GROUP)

                      AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                      TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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           UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: RER1
TYPE       PART OF MODEL                  SSH        SSE        MSH        MSE     F-RATIO     DFH       DFE    PROB

UNIV   GRAND MEAN                       81.15       0.22      81.15 0.8121E-2     8991.08     1.0      27.0 .313E-35
UNIV   GROUP                             0.01       0.22 0.3843E-2 0.8121E-2        0.47     3.0      27.0 0.70350
ERROR  TERM: CASES(GROUP)

UNIV   TIME                         0.1678E-2       0.05 0.1678E-2 0.1749E-2        0.96     1.0      27.0 0.33601
UNIV   GROUP*TIME                        0.03       0.05 0.9952E-2 0.1749E-2        5.69     3.0      27.0 0.00374
UNIV   CASES(GROUP)                 *    0.22       0.05 0.8121E-2 0.1749E-2        4.64    27.0      27.0 0.00008
UNIV   TIME*CASES(GROUP)            *    0.05       **** 0.1749E-2      ****        ****    27.0      ****    ****
ERROR  TERM: TIME*CASES(GROUP)

                      AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                      TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: HR1

TYPE      PART OF MODEL                        SSH        SSE         MSH       MSE    F-RATIO    DFH     DFE     PROB

UNIV  GRAND MEAN                          0.18941E7   8570.47 0.18941E7    317.42    5967.26    1.0    27.0 .321E-32
UNIV  GROUP                                  286.53   8570.47     95.51    317.42       0.30    3.0    27.0 0.82445
ERROR TERM: CASES(GROUP)

UNIV  TIME                                   233.66    914.47    233.66     33.87       6.90    1.0    27.0 0.01404
UNIV  GROUP*TIME                             124.01    914.47     41.34     33.87       1.22    3.0    27.0 0.32135
UNIV  CASES(GROUP)                      *   8570.47    914.47    317.42     33.87       9.37   27.0    27.0 0.610E-7
UNIV  TIME*CASES(GROUP)                 *    914.47      ****     33.87      ****       ****   27.0    ****     ****
ERROR TERM: TIME*CASES(GROUP)

                   AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                   TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.




          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: PO1

TYPE      PART OF MODEL                        SSH        SSE         MSH       MSE    F-RATIO    DFH     DFE     PROB

UNIV  GRAND MEAN                          0.18619E9 0.38551E7 0.18619E9 142783.07    1304.04    1.0    27.0 .215E-23
UNIV  GROUP                               320341.05 0.38551E7 106780.35 142783.07       0.75    3.0    27.0 0.53308
ERROR TERM: CASES(GROUP)

UNIV  TIME                                240582.22 248571.43 240582.22   9206.35      26.13    1.0    27.0 0.00002
UNIV  GROUP*TIME                          239170.51 248571.43  79723.50   9206.35       8.66    3.0    27.0 0.00034
UNIV  CASES(GROUP)                       *0.38551E7 248571.43 142783.07   9206.35      15.51   27.0    27.0 0.179E-9
UNIV  TIME*CASES(GROUP)                  *248571.43      ****   9206.35      ****       ****   27.0    ****     ****
ERROR TERM: TIME*CASES(GROUP)

                   AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                   TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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      UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: VEVO21

TYPE      PART OF MODEL                SSH       SSE       MSH       MSE    F-RATIO    DFH     DFE     PROB

UNIV  GRAND MEAN                   92102.56   2651.82  92102.56     98.22    937.76    1.0    27.0  .166E-21
UNIV  GROUP                          243.80   2651.82     81.27     98.22      0.83    3.0    27.0  0.49034
ERROR TERM: CASES(GROUP)

UNIV  TIME                            28.04    644.01     28.04     23.85      1.18    1.0    27.0  0.28781
UNIV  GROUP*TIME                     237.95    644.01     79.32     23.85      3.33    3.0    27.0  0.03447
UNIV  CASES(GROUP)               *  2651.82    644.01     98.22     23.85      4.12   27.0    27.0  0.00023
UNIV  TIME*CASES(GROUP)          *   644.01      ****     23.85      ****      ****   27.0    ****     ****
ERROR TERM: TIME*CASES(GROUP)

                  AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                  TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.




      UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: VEVC021

TYPE      PART OF MODEL                SSH       SSE       MSH       MSE    F-RATIO    DFH     DFE     PROB

UNIV  GRAND MEAN                   68850.67   1605.32  68850.67     59.46   1158.01    1.0    27.0  .103E-22
UNIV  GROUP                          140.41   1605.32     46.80     59.46      0.79    3.0    27.0  0.51157
ERROR TERM: CASES(GROUP)

UNIV  TIME                             0.88    474.75      0.88     17.58      0.05    1.0    27.0  0.82499
UNIV  GROUP*TIME                     233.50    474.75     77.83     17.58      4.43    3.0    27.0  0.01178
UNIV  CASES(GROUP)               *  1605.32    474.75     59.46     17.58      3.38   27.0    27.0  0.00115
UNIV  TIME*CASES(GROUP)          *   474.75      ****     17.58      ****      ****   27.0    ****     ****
ERROR TERM: TIME*CASES(GROUP)

                  AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                  TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: O2PULSE1

TYPE      PART OF MODEL                    SSH       SSE       MSH       MSE    F-RATIO     DFH     DFE    PROB

UNIV  GRAND MEAN                       22517.37    491.75  22517.37    18.21   1236.34     1.0    27.0 .436E-23
UNIV  GROUP                               13.21    491.75      4.40    18.21      0.24     3.0    27.0 0.86637
ERROR TERM: CASES(GROUP)

UNIV  TIME                                 8.54     35.09      8.54     1.30      6.57     1.0    27.0 0.01627
UNIV  GROUP*TIME                          12.19     35.09      4.06     1.30      3.13     3.0    27.0 0.04221
UNIV  CASES(GROUP)                   *   491.75     35.09     18.21     1.30     14.02    27.0    27.0 0.601E-9
UNIV  TIME*CASES(GROUP)              *    35.09      ****      1.30     ****      ****    27.0    ****    ****
ERROR TERM: TIME*CASES(GROUP)

                              AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                              TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.




        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: VO2L1

TYPE      PART OF MODEL                    SSH       SSE       MSH       MSE    F-RATIO     DFH     DFE    PROB

UNIV  GRAND MEAN                         309.51     11.06    309.51     0.41    755.65     1.0    27.0 .281E-20
UNIV  GROUP                                0.54     11.06      0.18     0.41      0.44     3.0    27.0 0.72937
ERROR TERM: CASES(GROUP)

UNIV  TIME                                 1.04      1.23      1.04     0.05     22.72     1.0    27.0 0.00006
UNIV  GROUP*TIME                           0.70      1.23      0.23     0.05      5.14     3.0    27.0 0.00608
UNIV  CASES(GROUP)                   *    11.06      1.23      0.41     0.05      8.99    27.0    27.0 0.967E-7
UNIV  TIME*CASES(GROUP)              *     1.23      ****      0.05     ****      ****    27.0    ****    ****
ERROR TERM: TIME*CASES(GROUP)

                              AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                              TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: VO2ML1
                                                    SSH        SSE        MSH        MSE     F-RATIO      DFH      DFE    PROB
TYPE      PART OF MODEL
                                               46848.19    1983.52   46848.19      73.46      637.71      1.0     27.0 .256E-19
UNIV  GRAND MEAN                                  46.15    1983.52      15.38      73.46        0.21      3.0     27.0 0.88900
UNIV  GROUP
ERROR TERM: CASES(GROUP)
                                                 169.84     182.04     169.84       6.74       25.19      1.0     27.0 0.00003
UNIV  TIME                                        95.09     182.04      31.70       6.74        4.70      3.0     27.0 0.00911
UNIV  GROUP*TIME                            *   1983.52     182.04      73.46       6.74       10.90     27.0     27.0 0.112E-7
UNIV  CASES(GROUP)                          *    182.04       ****       6.74       ****        ****     27.0     ****    ****
UNIV  TIME*CASES(GROUP)
ERROR TERM: TIME*CASES(GROUP)

                        AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                        TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: WT1
                                                    SSH        SSE        MSH        MSE     F-RATIO      DFH      DFE    PROB
TYPE      PART OF MODEL
                                              395787.38    4339.24  395787.38     166.89     2371.49      1.0     26.0 .446E-26
UNIV  GRAND MEAN                                 937.97    4339.24     312.66     166.89        1.87      3.0     26.0 0.15888
UNIV  GROUP
ERROR TERM: CASES(GROUP)
                                              0.5194E-3      19.67  0.5194E-3       0.76  0.6867E-3      1.0     26.0 0.97929
UNIV  TIME                                        10.44      19.67       3.48       0.76        4.60      3.0     26.0 0.01036
UNIV  GROUP*TIME                            *   4339.24      19.67     166.89       0.76      220.62     26.0     26.0 .158E-23
UNIV  CASES(GROUP)                          *     19.67       ****       0.76       ****        ****     26.0     ****    ****
UNIV  TIME*CASES(GROUP)
ERROR TERM: TIME*CASES(GROUP)

                        AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                        TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: VE1
TYPE       PART OF MODEL                     SSH         SSE        MSH         MSE       F-RATIO     DFH      DFE     PROB

UNIV  GRAND MEAN                          193046.24    6305.96  193046.24     242.54      795.95      1.0     26.0  .499E-20
UNIV  GROUP                                  551.00    6305.96     183.67     242.54        0.76      3.0     26.0  0.52823
ERROR TERM: CASES(GROUP)

UNIV  TIME                                  1019.04    1308.01    1019.04      50.31       20.26      1.0     26.0  0.00013
UNIV  GROUP*TIME                             777.16    1308.01     259.05      50.31        5.15      3.0     26.0  0.00629
UNIV  CASES(GROUP)                      *   6305.96    1308.01     242.54      50.31        4.82     26.0     26.0  0.00007
UNIV  TIME*CASES(GROUP)                 *   1308.01       ****      50.31       ****        ****     26.0     ****     ****
ERROR TERM: TIME*CASES(GROUP)

                        AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                        TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.


          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: VC021
TYPE       PART OF MODEL                     SSH         SSE        MSH         MSE       F-RATIO     DFH      DFE     PROB

UNIV  GRAND MEAN                             276.33       9.78     276.33       0.38      734.67      1.0     26.0  .136E-19
UNIV  GROUP                                    0.78       9.78       0.26       0.38        0.70      3.0     26.0  0.56334
ERROR TERM: CASES(GROUP)

UNIV  TIME                                     1.31       2.43       1.31       0.09       13.99      1.0     26.0  0.00092
UNIV  GROUP*TIME                               1.10       2.43       0.37       0.09        3.93      3.0     26.0  0.01950
UNIV  CASES(GROUP)                      *      9.78       2.43       0.38       0.09        4.03     26.0     26.0  0.00035
UNIV  TIME*CASES(GROUP)                 *      2.43       ****       0.09       ****        ****     26.0     ****     ****
ERROR TERM: TIME*CASES(GROUP)

                        AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                        TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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         UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: RER1
                                                                                    
                                              SSH       SSE        MSH        MSE    F-RATIO     DFH     DFE   PROB
TYPE      PART OF MODEL                                                           16391.44      1.0    26.0 .611E-37
                                              53.73      0.09      53.73 0.3277E-2     0.57      3.0    26.0 0.63713
UNIV  GRAND MEAN                           0.5645E-2     0.09 0.1881E-2 0.3277E-2
UNIV  GROUP
ERROR TERM: CASES(GROUP)                                                               1.70      1.0    26.0 0.20374
                                           0.5195E-2     0.08 0.5195E-2 0.3056E-2      2.64      3.0    26.0 0.07067
UNIV  TIME                                      0.02     0.08 0.8065E-2 0.3056E-2      1.07     26.0    26.0 0.42998
UNIV  GROUP*TIME                          *     0.09     0.08 0.3277E-2 0.3056E-2      ****     26.0    ****   ****
UNIV  CASES(GROUP)                        *     0.08     **** 0.3056E-2      ****
UNIV  TIME*CASES(GROUP)
ERROR TERM: TIME*CASES(GROUP)

                          AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                          TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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         UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: HR1

                                              SSH       SSE        MSH        MSE    F-RATIO     DFH     DFE   PROB
TYPE      PART OF MODEL                                                 470.20     2424.47      1.0    26.0 .336E-26
                                          0.11399E7  12225.10 0.11399E7  470.20       0.13      3.0    26.0 0.94433
UNIV  GRAND MEAN                             176.65  12225.10     58.88
UNIV  GROUP
ERROR TERM: CASES(GROUP)                                                 103.66       4.73      1.0    26.0 0.03883
                                             490.80   2695.10    490.80  103.66       3.36      3.0    26.0 0.03398
UNIV  TIME                                  1044.39   2695.10    348.13  103.66       4.54     26.0    26.0 0.00013
UNIV  GROUP*TIME                          * 12225.10  2695.10    470.20    ****       ****     26.0    ****   ****
UNIV  CASES(GROUP)                        *  2695.10     ****    103.66
UNIV  TIME*CASES(GROUP)
ERROR TERM: TIME*CASES(GROUP)

                          AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                          TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: P01

TYPE      PART OF MODEL                       SSH        SSE        MSH        MSE      F-RATIO    DFH     DFE    PROB

UNIV  GRAND MEAN                       0.71097E8 0.32075E7 0.71097E8 123365.38     576.32     1.0    26.0 .285E-18
UNIV  GROUP                            171833.34 0.32075E7  57277.78 123365.38       0.46     3.0    26.0 0.70966
ERROR TERM: CASES(GROUP)

UNIV  TIME                             145167.26 415753.97 145167.26  15990.54       9.08     1.0    26.0 0.00570
UNIV  GROUP*TIME                        94246.03 415753.97  31415.34  15990.54       1.96     3.0    26.0 0.14406
UNIV  CASES(GROUP)                    *0.32075E7 415753.97 123365.38  15990.54       7.71    26.0    26.0 0.808E-6
UNIV  TIME*CASES(GROUP)               *415753.97      ****  15990.54      ****       ****    26.0    ****    ****
ERROR TERM: TIME*CASES(GROUP)

                        AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                        TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.




        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: VEV021

TYPE      PART OF MODEL                       SSH        SSE        MSH        MSE      F-RATIO    DFH     DFE    PROB

UNIV  GRAND MEAN                        38139.84     547.55  38139.84     21.06    1811.05     1.0    26.0 .142E-24
UNIV  GROUP                                65.87     547.55     21.96     21.06       1.04     3.0    26.0 0.39024
ERROR TERM: CASES(GROUP)

UNIV  TIME                                  7.97      88.37      7.97      3.40       2.34     1.0    26.0 0.13778
UNIV  GROUP*TIME                           11.14      88.37      3.71      3.40       1.09     3.0    26.0 0.36967
UNIV  CASES(GROUP)                    *   547.55      88.37     21.06      3.40       6.20    26.0    26.0 0.719E-5
UNIV  TIME*CASES(GROUP)               *    88.37       ****      3.40      ****       ****    26.0    ****    ****
ERROR TERM: TIME*CASES(GROUP)

                        AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                        TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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            UNIQUE          SUMMARY-TABLE OF F-RATIOS FOR: VEVCO21
                                           SSH         SSE       MSH          MSE      F-RATIO    DFH     DFE    PROB
TYPE        PART OF MODEL                                                                                  
                                        41639.41     487.53  41639.41       18.75    2220.64     1.0    26.0 .104E-25
UNIV  GRAND MEAN                           45.74     487.53     15.25       18.75       0.81     3.0    26.0 0.49821
UNIV  GROUP
ERROR TERM: CASES(GROUP)
                                            1.83      47.47      1.83        1.83       1.00     1.0    26.0 0.32555
UNIV  TIME                                 13.37      47.47      4.46        1.83       2.44     3.0    26.0 0.08683
UNIV  GROUP*TIME                     *    487.53      47.47     18.75        1.83      10.27    26.0    26.0 0.392E-7
UNIV  CASES(GROUP)                   *     47.47       ****      1.83        ****       ****    26.0    ****   ****
UNIV  TIME*CASES(GROUP)
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.




            UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: O2PULSE1
                                           SSH         SSE       MSH          MSE      F-RATIO    DFH     DFE    PROB
TYPE        PART OF MODEL                                                                                  
                                        15412.63     419.28  15412.63       16.13     955.75     1.0    26.0 .494E-21
UNIV  GRAND MEAN                           19.38     419.28      6.46       16.13       0.40     3.0    26.0 0.75373
UNIV  GROUP
ERROR TERM: CASES(GROUP)
                                           23.10      20.16     23.10        0.78      29.79     1.0    26.0 0.00001
UNIV  TIME                                  9.45      20.16      3.15        0.78       4.06     3.0    26.0 0.01709
UNIV  GROUP*TIME                     *    419.28      20.16     16.13        0.78      20.80    26.0    26.0 .123E-10
UNIV  CASES(GROUP)                   *     20.16       ****      0.78        ****       ****    26.0    ****   ****
UNIV  TIME*CASES(GROUP)
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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      UNIQUE         SUMMARY TABLE OF F-RATIOS FOR: WT1

TYPE      PART OF MODEL                    SSH        SSE       MSH        MSE      F-RATIO     DFH     DFE    PROB

UNIV  GRAND MEAN                      816402.81   10356.34 816402.81    493.16    1655.45      1.0     21.0 .184E-20
UNIV  GROUP                             1838.36   10356.34    919.18    493.16       1.86      2.0     21.0 0.17983
ERROR TERM: CASES(GROUP)

UNIV  TIME                                 0.98      56.24      0.24      0.67       0.37      4.0     84.0 0.83285
 GREENHOUSE-GEISER ADJ:                EPSILON:       0.77      0.24      0.67       0.37      3.1     64.4 0.78267
UNIV  GROUP*TIME                          11.21      56.24      1.40      0.67       2.09      8.0     84.0 0.04532
 GREENHOUSE-GEISER ADJ:                EPSILON:       0.77      1.40      0.67       2.09      6.1     64.4 0.06477
UNIV  CASES(GROUP)                    * 10356.34     56.24    493.16      0.67     736.52     21.0     84.0 0.0
UNIV  TIME*CASES(GROUP)               *    56.24      ****      0.67      ****       ****     84.0     ****   ****
ERROR TERM: TIME*CASES(GROUP)

                          AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                          TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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      UNIQUE         SUMMARY TABLE OF F-RATIOS FOR: VE1

TYPE      PART OF MODEL                    SSH        SSE       MSH        MSE      F-RATIO     DFH     DFE    PROB

UNIV  GRAND MEAN                      0.23825E7   72403.98 0.23825E7   3447.81     691.03      1.0     21.0 .149E-16
UNIV  GROUP                             1147.65   72403.98    573.82   3447.81       0.17      2.0     21.0 0.84779
ERROR TERM: CASES(GROUP)

UNIV  TIME                              4424.68    9103.28   1106.17    108.37      10.21      4.0     84.0 0.876E-6
 GREENHOUSE-GEISER ADJ:                EPSILON:       0.87   1106.17    108.37      10.21      3.5     72.7 0.395E-5
UNIV  GROUP*TIME                        1403.03    9103.28    175.38    108.37       1.62      8.0     84.0  0.13177
 GREENHOUSE-GEISER ADJ:                EPSILON:       0.87    175.38    108.37       1.62      6.9     72.7  0.14464
UNIV  CASES(GROUP)                    * 72403.98   9103.28   3447.81    108.37      31.81     21.0     84.0 .242E-30
UNIV  TIME*CASES(GROUP)               *  9103.28      ****    108.37      ****       ****     84.0     ****   ****
ERROR TERM: TIME*CASES(GROUP)

                          AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                          TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: VO2L1
TYPE       PART OF MODEL                     SSH       SSE       MSH       MSE    F-RATIO     DFH     DFE   PROB

UNIV  GRAND MEAN                         1436.10     32.00   1436.10      1.52     942.31     1.0    21.0 .622E-18
UNIV  GROUP                                 2.29     32.00      1.15      1.52       0.75     2.0    21.0 0.48328
ERROR TERM: CASES(GROUP)

UNIV  TIME                                  1.71      2.33      0.43      0.03      15.43     4.0    84.0 0.168E-8
 GREENHOUSE-GEISER ADJ:                 EPSILON:      0.86      0.43      0.03      15.43     3.4    72.3 0.329E-7
UNIV  GROUP*TIME                            0.43      2.33      0.05      0.03       1.95     8.0    84.0  0.06262
 GREENHOUSE-GEISER ADJ:                 EPSILON:      0.86      0.05      0.03       1.95     6.9    72.3  0.07463
UNIV  CASES(GROUP)                    *    32.00      2.33      1.52      0.03      54.86    21.0    84.0 .328E-39
UNIV  TIME*CASES(GROUP)               *     2.33      ****      0.03      ****       ****    84.0    ****    ****
ERROR TERM: TIME*CASES(GROUP)

                     AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                     TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: VO2ML1
TYPE       PART OF MODEL                     SSH       SSE       MSH       MSE    F-RATIO     DFH     DFE   PROB

UNIV  GRAND MEAN                       216118.86   8315.49 216118.86    395.98     545.79     1.0    21.0 .164E-15
UNIV  GROUP                               538.04   8315.49    269.02    395.98       0.68     2.0    21.0 0.51772
ERROR TERM: CASES(GROUP)

UNIV  TIME                                281.64    389.14     70.41      4.63      15.20     4.0    84.0 0.218E-8
 GREENHOUSE-GEISER ADJ:                 EPSILON:      0.80     70.41      4.63      15.20     3.2    66.9 0.109E-6
UNIV  GROUP*TIME                           60.90    389.14      7.61      4.63       1.64     8.0    84.0  0.12485
 GREENHOUSE-GEISER ADJ:                 EPSILON:      0.80      7.61      4.63       1.64     6.4    66.9  0.14504
UNIV  CASES(GROUP)                    *  8315.49    389.14    395.98      4.63      85.48    21.0    84.0 .946E-47
UNIV  TIME*CASES(GROUP)               *   389.14      ****      4.63      ****       ****    84.0    ****    ****
ERROR TERM: TIME*CASES(GROUP)

                     AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                     TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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        UNIQUE           SUMMARY TABLE OF F-RATIOS FOR: VCOL1

TYPE      PART OF MODEL                        SSH        SSE        MSH        MSE      F-RATIO     DFH      DFE    PROB

UNIV  GRAND MEAN                           1894.43      40.20    1894.43       1.91      989.53      1.0     21.0  .376E-18
UNIV  GROUP                                   2.78      40.20       1.39       1.91        0.72      2.0     21.0  0.49606
ERROR TERM: CASES(GROUP)

UNIV  TIME                                    1.46       3.84       0.36       0.05        7.98      4.0     84.0  0.00002
 GREENHOUSE-GEISER ADJ:                   EPSILON:       0.82       0.36       0.05        7.98      3.3     68.5  0.00008
UNIV  GROUP*TIME                              0.99       3.84       0.12       0.05        2.70      8.0     84.0  0.01073
 GREENHOUSE-GEISER ADJ:                   EPSILON:       0.82       0.12       0.05        2.70      6.5     68.3  0.01777
UNIV  CASES(GROUP)                      *    40.20       3.84       1.91       0.05       41.89     21.0     84.0  .940E-35
UNIV  TIME*CASES(GROUP)                 *     3.84       ****       0.05       ****        ****     84.0     ****    ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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        UNIQUE           SUMMARY TABLE OF F-RATIOS FOR: RER1

TYPE      PART OF MODEL                        SSH        SSE        MSH        MSE      F-RATIO     DFH      DFE    PROB

UNIV  GRAND MEAN                            157.14       0.25     157.14       0.01    13353.10      1.0     21.0  .621E-30
UNIV  GROUP                                   0.03       0.25       0.02       0.01        1.47      2.0     21.0  0.25287
ERROR TERM: CASES(GROUP)

UNIV  TIME                                    0.05       0.20       0.01 0.2411E-2         5.40      4.0     84.0  0.00064
 GREENHOUSE-GEISER ADJ:                   EPSILON:       0.76       0.01 0.2411E-2         5.40      3.0     64.0  0.00214
UNIV  GROUP*TIME                              0.02       0.20 0.1979E-2 0.2411E-2         0.82      8.0     84.0  0.58635
 GREENHOUSE-GEISER ADJ:                   EPSILON:       0.76 0.1979E-2 0.2411E-2         0.82      6.1     64.0  0.55949
UNIV  CASES(GROUP)                      *     0.25       0.20       0.01 0.2411E-2         4.88     21.0     84.0 0.818E-7
UNIV  TIME*CASES(GROUP)                 *     0.20       **** 0.2411E-2       ****        ****     84.0     ****    ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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           UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: HR1

TYPE       PART OF MODEL                    SSH        SSE        MSH        MSE     F-RATIO    DFH    DFE    PROB

UNIV  GRAND MEAN                       0.37660E7   13646.92 0.37660E7     649.85    5795.22     1.0   21.0 .389E-26
UNIV  GROUP                               495.48   13646.92    247.74     649.85       0.38     2.0   21.0 0.68766
ERROR TERM: CASES(GROUP)

UNIV  TIME                                520.76    2549.81    130.19      30.35       4.29     4.0   84.0 0.00331
 GREENHOUSE-GEISER ADJ:                 EPSILON:       0.62    130.19      30.35       4.29     2.5   51.7 0.01321
UNIV  GROUP*TIME                          309.09    2549.81     38.64      30.35       1.27     8.0   84.0 0.26871
 GREENHOUSE-GEISER ADJ:                 EPSILON:       0.62     38.64      30.35       1.27     4.9   51.7 0.29006
UNIV  CASES(GROUP)                     * 13646.92   2549.81    649.85      30.35      21.41    21.0   84.0 .271E-24
UNIV  TIME*CASES(GROUP)                *  2549.81      ****     30.35       ****       ****    84.0   ****   ****
ERROR TERM: TIME*CASES(GROUP)

                       AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                       TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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           UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: PO1

TYPE       PART OF MODEL                    SSH        SSE        MSH        MSE     F-RATIO    DFH    DFE    PROB

UNIV  GRAND MEAN                      0.38997E9 0.77400E7 0.38997E9  368571.43    1058.06     1.0   21.0 .188E-18
UNIV  GROUP                           275666.67 0.77400E7 137833.33  368571.43       0.37     2.0   21.0 0.69249
ERROR TERM: CASES(GROUP)

UNIV  TIME                            0.11179E7 594444.44 279493.56    7076.72      39.49     4.0   84.0 .142E-17
 GREENHOUSE-GEISER ADJ:                 EPSILON:       0.88 279493.56    7076.72      39.49     3.5   74.2 .115E-15
UNIV  GROUP*TIME                       64888.89 594444.44   8111.11    7076.72       1.15     8.0   84.0 0.34165
 GREENHOUSE-GEISER ADJ:                 EPSILON:       0.88   8111.11    7076.72       1.15     7.1   74.2 0.34413
UNIV  CASES(GROUP)                    *0.77400E7 594444.44 368571.43    7076.72      52.08    21.0   84.0 .241E-38
UNIV  TIME*CASES(GROUP)               *594444.44      ****   7076.72       ****       ****    84.0   ****   ****
ERROR TERM: TIME*CASES(GROUP)

                       AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                       TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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        UNIQUE           SUMMARY TABLE OF F-RATIOS FOR: VEV01

TYPE      PART OF MODEL                       SSH        SSE        MSH       MSE    F-RATIO     DFH      DFE     PROB

UNIV  GRAND MEAN                          198386.84    3039.22 198386.84    144.72    1370.79     1.0     21.0 .130E-19
UNIV  GROUP                                  121.58    3039.22     60.79    144.72       0.42     2.0     21.0 0.66241
ERROR TERM: CASES(GROUP)

UNIV  TIME                                    40.24     701.44     10.06      8.35       1.20     4.0     84.0 0.31498
 GREENHOUSE-GEISER ADJ:                    EPSILON:       0.83     10.06      8.35       1.20     3.3     69.9 0.31567
UNIV  GROUP*TIME                              28.55     701.44      3.57      8.35       0.43     8.0     84.0 0.90153
 GREENHOUSE-GEISER ADJ:                    EPSILON:       0.83      3.57      8.35       0.43     6.7     69.9 0.87446
UNIV  CASES(GROUP)                      *   3039.22     701.44    144.72      8.35      17.33    21.0     84.0 .301E-21
UNIV  TIME*CASES(GROUP)                 *    701.44       ****      8.35      ****       ****    84.0     ****     ****
ERROR TERM: TIME*CASES(GROUP)

                         AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                         TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.


        UNIQUE           SUMMARY TABLE OF F-RATIOS FOR: VEVC01

TYPE      PART OF MODEL                       SSH        SSE        MSH       MSE    F-RATIO     DFH      DFE     PROB

UNIV  GRAND MEAN                          149809.45    2097.01 149809.45     99.86    1500.23     1.0     21.0 .511E-20
UNIV  GROUP                                   75.89    2097.01     37.94     99.86       0.38     2.0     21.0 0.68849
ERROR TERM: CASES(GROUP)

UNIV  TIME                                   139.52     367.91     34.88      4.38       7.96     4.0     84.0 0.00002
 GREENHOUSE-GEISER ADJ:                    EPSILON:       0.82     34.88      4.38       7.96     3.3     68.6 0.00008
UNIV  GROUP*TIME                              13.44     367.91      1.68      4.38       0.38     8.0     84.0 0.92654
 GREENHOUSE-GEISER ADJ:                    EPSILON:       0.82      1.68      4.38       0.38     6.5     68.6 0.89931
UNIV  CASES(GROUP)                      *   2097.01     367.91     99.86      4.38      22.80    21.0     84.0 .317E-25
UNIV  TIME*CASES(GROUP)                 *    367.91       ****      4.38      ****       ****    84.0     ****     ****
ERROR TERM: TIME*CASES(GROUP)

                         AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                         TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: O2PULSE1

TYPE      PART OF MODEL                 SSH         SSE        MSH        MSE     F-RATIO     DFH      DFE    PROB

UNIV  GRAND MEAN                     45200.24     765.36   45200.24     36.45    1240.21      1.0     21.0 .366E-19
UNIV  GROUP                             73.60     765.36      36.80     36.45       1.01      2.0     21.0 0.38134
ERROR TERM: CASES(GROUP)

UNIV  TIME                              27.87      94.63       6.97      1.13       6.18      4.0     84.0 0.00021
 GREENHOUSE-GEISER ADJ:              EPSILON:       0.73       6.97      1.13       6.18      2.9     61.2 0.00108
UNIV  GROUP*TIME                         7.07      94.63       0.88      1.13       0.78      8.0     84.0 0.61725
 GREENHOUSE-GEISER ADJ:              EPSILON:       0.73       0.88      1.13       0.78      5.8     61.2 0.58185
UNIV  CASES(GROUP)                 *   765.36      94.63      36.45      1.13      32.35     21.0     84.0 .131E-30
UNIV  TIME*CASES(GROUP)            *    94.63       ****       1.13      ****       ****     84.0     ****   ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.


          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: WT1

TYPE      PART OF MODEL                 SSH         SSE        MSH        MSE     F-RATIO     DFH      DFE    PROB

UNIV  GRAND MEAN                    822394.27   10313.89 822394.27    491.14    1674.47      1.0     21.0 .163E-20
UNIV  GROUP                           1874.33   10313.89    937.16    491.14       1.91      2.0     21.0 0.17321
ERROR TERM: CASES(GROUP)

UNIV  TIME                               1.34      51.32       0.34      0.61       0.55      4.0     84.0 0.69980
 GREENHOUSE-GEISER ADJ:              EPSILON:       0.76       0.34      0.61       0.55      3.0     63.6 0.65181
UNIV  GROUP*TIME                        13.38      51.32       1.67      0.61       2.74      8.0     84.0 0.00982
 GREENHOUSE-GEISER ADJ:              EPSILON:       0.76       1.67      0.61       2.74      6.1     63.6 0.01950
UNIV  CASES(GROUP)                 * 10313.89      51.32     491.14      0.61     803.92     21.0     84.0 0.0
UNIV  TIME*CASES(GROUP)            *    51.32       ****       0.61      ****       ****     84.0     ****   ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: VE1

TYPE      PART OF MODEL                          SSH       SSE       MSH       MSE    F-RATIO    DFH     DFE    PROB

UNIV  GRAND MEAN                           419964.36  11681.01 419964.36    556.24    755.01    1.0    21.0 .603E-17
UNIV  GROUP                                  1476.01  11681.01    738.01    556.24      1.33    2.0    21.0 0.28667
ERROR TERM: CASES(GROUP)

UNIV  TIME                                   1570.96   4021.65    392.74     47.88      8.20    4.0    84.0 0.00001
 GREENHOUSE-GEISER ADJ:                     EPSILON:      0.83    392.74     47.88      8.20    3.3    70.0 0.00005
UNIV  GROUP*TIME                              900.01   4021.65    112.50     47.88      2.35    8.0    84.0 0.02483
 GREENHOUSE-GEISER ADJ:                     EPSILON:      0.83    112.50     47.88      2.35    6.7    70.0 0.03480
UNIV  CASES(GROUP)                        * 11681.01   4021.65    556.24     47.88     11.62   21.0    84.0 .650E-16
UNIV  TIME*CASES(GROUP)                   *  4021.65      ****     47.88      ****      ****   84.0    ****    ****
ERROR TERM: TIME*CASES(GROUP)

                      AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                      TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.



        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: VO2L1

TYPE      PART OF MODEL                          SSH       SSE       MSH       MSE    F-RATIO    DFH     DFE    PROB

UNIV  GRAND MEAN                              624.49     18.61    624.49      0.89    704.76    1.0    21.0 .122E-16
UNIV  GROUP                                     1.87     18.61      0.93      0.89      1.05    2.0    21.0 0.36650
ERROR TERM: CASES(GROUP)

UNIV  TIME                                      1.47      3.11      0.37      0.04      9.93    4.0    84.0 0.124E-5
 GREENHOUSE-GEISER ADJ:                     EPSILON:      0.86      0.37      0.04      9.93    3.4    72.3 0.562E-5
UNIV  GROUP*TIME                                0.79      3.11      0.10      0.04      2.66    8.0    84.0 0.01174
 GREENHOUSE-GEISER ADJ:                     EPSILON:      0.86      0.10      0.04      2.66    6.8    72.3 0.01697
UNIV  CASES(GROUP)                        *    18.61      3.11      0.89      0.04     23.93   21.0    84.0 .594E-26
UNIV  TIME*CASES(GROUP)                   *     3.11      ****      0.04      ****      ****   84.0    ****    ****
ERROR TERM: TIME*CASES(GROUP)

                      AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                      TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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      UNIQUE           SUMMARY TABLE OF F-RATIOS FOR: VO2ML1
                                       SSH       SSE       MSH       MSE    F-RATIO    DFH    DFE    PROB
TYPE       PART OF MODEL
UNIV  GRAND MEAN                  93185.68   4219.10  93185.68    200.91    463.82    1.0   21.0 .849E-15
UNIV  GROUP                         212.73   4219.10    106.37    200.91      0.53    2.0   21.0  0.59660
ERROR TERM: CASES(GROUP)

UNIV  TIME                          248.45    467.01     62.11      5.56     11.17    4.0   84.0 0.258E-6
  GREENHOUSE-GEISER ADJ:          EPSILON:      0.87     62.11      5.56     11.17    3.5   73.4 0.125E-5
UNIV  GROUP*TIME                    109.02    467.01     13.63      5.56      2.45    8.0   84.0  0.01953
  GREENHOUSE-GEISER ADJ:          EPSILON:      0.87     13.63      5.56      2.45    7.0   73.4  0.02582
UNIV  CASES(GROUP)               *  4219.10    467.01    200.91      5.56     36.14   21.0   84.0 .229E-32
UNIV  TIME*CASES(GROUP)          *   467.01      ****      5.56      ****      ****   84.0   ****    ****
ERROR TERM: TIME*CASES(GROUP)

                  AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                  TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.


      UNIQUE           SUMMARY TABLE OF F-RATIOS FOR: VCOL1
                                       SSH       SSE       MSH       MSE    F-RATIO    DFH    DFE    PROB
TYPE       PART OF MODEL
UNIV  GRAND MEAN                    570.53     17.03    570.53      0.81    703.50    1.0   21.0 .124E-16
UNIV  GROUP                           2.15     17.03      1.08      0.81      1.33    2.0   21.0  0.28663
ERROR TERM: CASES(GROUP)

UNIV  TIME                            2.03      5.26      0.51      0.06      8.10    4.0   84.0  0.00001
  GREENHOUSE-GEISER ADJ:          EPSILON:      0.88      0.51      0.06      8.10    3.5   73.7  0.00004
UNIV  GROUP*TIME                      1.19      5.26      0.15      0.06      2.38    8.0   84.0  0.02311
  GREENHOUSE-GEISER ADJ:          EPSILON:      0.88      0.15      0.06      2.38    7.0   73.7  0.02982
UNIV  CASES(GROUP)               *   17.03      5.26      0.81      0.06     12.96   21.0   84.0 .259E-17
UNIV  TIME*CASES(GROUP)          *     5.26      ****      0.06      ****      ****   84.0   ****    ****
ERROR TERM: TIME*CASES(GROUP)

                  AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                  TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: RER1

TYPE      PART OF MODEL                          SSH       SSE        MSH        MSE     F-RATIO    DFH      DFE    PROB

UNIV  GRAND MEAN                               108.17      0.13     108.17 0.6141E-2   17613.22     1.0     21.0 .340E-31
UNIV  GROUP                                      0.02      0.13 0.9475E-2 0.6141E-2       1.54     2.0     21.0 0.23704
ERROR TERM: CASES(GROUP)

UNIV  TIME                                       0.07      0.20       0.02 0.2361E-2       7.00     4.0     84.0 0.00007
 GREENHOUSE-GEISER ADJ:                      EPSILON:      0.77       0.02 0.2361E-2       7.00     3.1     64.3 0.00035
UNIV  GROUP*TIME                                 0.01      0.20 0.1811E-2 0.2361E-2       0.77     8.0     84.0 0.63268
 GREENHOUSE-GEISER ADJ:                      EPSILON:      0.77 0.1811E-2 0.2361E-2       0.77     6.1     64.3 0.60100
UNIV  CASES(GROUP)                           *   0.13      0.20 0.6141E-2 0.2361E-2       2.60    21.0     84.0 0.00109
UNIV  TIME*CASES(GROUP)                      *   0.20      **** 0.2361E-2      ****       ****    84.0     ****    ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.



        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR; HR1

TYPE      PART OF MODEL                          SSH       SSE        MSH        MSE     F-RATIO    DFH      DFE    PROB

UNIV  GRAND MEAN                           0.22872E7  20617.24  0.22872E7     981.77    2329.67     1.0     21.0 .528E-22
UNIV  GROUP                                    705.13  20617.24     352.56     981.77       0.36     2.0     21.0 0.70250
ERROR TERM: CASES(GROUP)

UNIV  TIME                                     429.74   5629.86     107.44      67.02       1.60     4.0     84.0 0.18112
 GREENHOUSE-GEISER ADJ:                      EPSILON:      0.84     107.44      67.02       1.60     3.4     70.8 0.19142
UNIV  GROUP*TIME                              1240.02   5629.86     155.00      67.02       2.31     8.0     84.0 0.02711
 GREENHOUSE-GEISER ADJ:                      EPSILON:      0.84     155.00      67.02       2.31     6.7     70.8 0.03682
UNIV  CASES(GROUP)                         * 20617.24   5629.86     981.77      67.02      14.65    21.0     84.0 .624E-19
UNIV  TIME*CASES(GROUP)                    *  5629.86      ****      67.02       ****       ****    84.0     ****    ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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          UNIQUE         -   SUMMARY TABLE OF F-RATIOS FOR: P01
                                                         SSH         SSE          MSH         MSE          F-RATIO     DFH      DFE     PROB
TYPE      PART OF MODEL
                                                   0.15525E9 0.55718E7 0.15525E9 265327.29     585.13       1.0      21.0 .810E-16
UNIV  GRAND MEAN                                   315793.65 0.55718E7 157896.83 265327.29       0.60       2.0      21.0 0.56054
UNIV  GROUP
ERROR TERM: CASES(GROUP)
                                                   206830.02 0.13727E7  51707.51  16342.03       3.16       4.0      84.0 0.01790
UNIV  TIME                                           EPSILON:      0.79  51707.51  16342.03       3.16       3.2      66.8 0.02771
  GREENHOUSE-GEISER ADJ:                           157936.[illegible] 0.13727E7  19742.06  16342.03       1.21       8.0      84.0 0.30434
UNIV  GROUP*TIME                                     EPSILON:      0.79  19742.06  16342.03       1.21       6.4      66.8 0.31235
  GREENHOUSE-GEISER ADJ:                          *0.55718E7 0.13727E7 265327.29  16342.03      16.24      21.0      84.0 .245E-20
UNIV  CASES(GROUP)                                *0.13727E7      ****  16342.03      ****       ****      84.0      ****     ****
UNIV  TIME*CASES(GROUP)
ERROR TERM: TIME*CASES(GROUP)

                        AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                        TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.


          UNIQUE             SUMMARY TABLE OF F-RATIOS FOR: VEVO1

TYPE      PART OF MODEL                                  SSH         SSE          MSH         MSE          F-RATIO     DFH      DFE     PROB

                                                    80273.84      859.68   80273.84      40.94    1960.90       1.0      21.0 .317E-21
UNIV  GRAND MEAN                                      117.13      859.68      58.56      40.94       1.43       2.0      21.0 0.26155
UNIV  GROUP
ERROR TERM: CASES(GROUP)
                                                       17.06      252.18       4.27       3.00       1.42       4.0      84.0 0.23418
UNIV  TIME                                          EPSILON:        0.72       4.27       3.00       1.42       2.9      60.6 0.24619
  GREENHOUSE-GEISER ADJ:                               13.83      252.18       1.73       3.00       0.58       8.0      84.0 0.79484
UNIV  GROUP*TIME                                    EPSILON:        0.72       1.73       3.00       0.58       5.8      60.6 0.74148
  GREENHOUSE-GEISER ADJ:                       *      859.68      252.18      40.94       3.00      13.64      21.0      84.0 .563E-18
UNIV  CASES(GROUP)                             *      252.18        ****       3.00       ****       ****      84.0      ****     ****
UNIV  TIME*CASES(GROUP)
ERROR TERM: TIME*CASES(GROUP)

                        AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                        TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: VEVC01

TYPE      PART OF MODEL                    SSH        SSE        MSH        MSE      F-RATIO     DFH     DFE     PROB

UNIV  GRAND MEAN                      88186.18     817.13   88186.18      38.91     2266.37     1.0    21.0 .704E-22
UNIV  GROUP                              65.97     817.13      32.99      38.91        0.85     2.0    21.0 0.44254
ERROR TERM: CASES(GROUP)

UNIV  TIME                               54.41     127.85      13.60       1.52        8.94     4.0    84.0 0.461E-5
 GREENHOUSE-GEISER ADJ:               EPSILON:       0.85      13.60       1.52        8.94     3.4    71.2  0.00002
UNIV  GROUP*TIME                          1.19     127.85       0.15       1.52        0.10     8.0    84.0  0.99920
 GREENHOUSE-GEISER ADJ:               EPSILON:       0.85       0.15       1.52        0.10     6.8    71.2  0.99800
UNIV  CASES(GROUP)                   *  817.13     127.85      38.91       1.52       25.56    21.0    84.0 .595E-27
UNIV  TIME*CASES(GROUP)              *  127.85       ****       1.52       ****        ****    84.0    ****    ****
ERROR TERM: TIME*CASES(GROUP)

                   AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                   TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.


          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: O2PULSE1

TYPE      PART OF MODEL                    SSH        SSE        MSH        MSE      F-RATIO     DFH     DFE     PROB

UNIV  GRAND MEAN                      32262.53     625.77   32262.53      29.80     1082.69     1.0    21.0 .148E-18
UNIV  GROUP                              49.35     625.77      24.67      29.80        0.83     2.0    21.0 0.45067
ERROR TERM: CASES(GROUP)

UNIV  TIME                               48.08      67.44      12.02       0.80       14.97     4.0    84.0 0.281E-8
 GREENHOUSE-GEISER ADJ:               EPSILON:       0.83      12.02       0.80       14.97     3.3    70.0 0.115E-6
UNIV  GROUP*TIME                          7.25      67.44       0.91       0.80        1.13     8.0    84.0  0.35294
 GREENHOUSE-GEISER ADJ:               EPSILON:       0.83       0.91       0.80        1.13     6.7    70.0  0.35541
UNIV  CASES(GROUP)                   *  625.77      67.44      29.80       0.80       37.11    21.0    84.0 .856E-33
UNIV  TIME*CASES(GROUP)              *   67.44       ****       0.80       ****        ****    84.0    ****    ****
ERROR TERM: TIME*CASES(GROUP)

                   AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                   TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: V1

TYPE        PART OF MODEL                SSH        SSE        MSH        MSE     F-RATIO     DFH      DFE     PROB

UNIV   GRAND MEAN                  401793.94    4383.44  401793.94     162.35     2474.87     1.0     27.0  .427E-27
UNIV   GROUP                          928.91    4383.44     309.64     162.35        1.91     3.0     27.0  0.15224
ERROR  TERM: CASES(GROUP)

UNIV   TIME                             0.40      17.02       0.40       0.63        0.63     1.0     27.0  0.43541
UNIV   GROUP*TIME                      14.71      17.02       4.90       0.63        7.77     3.0     27.0  0.00067
UNIV   CASES(GROUP)               *  4383.44      17.02     162.35       0.63      257.51    27.0     27.0  .263E-25
UNIV   TIME*CASES(GROUP)          *    17.02       ****       0.63       ****        ****    27.0     ****     ****
ERROR  TERM: TIME*CASES(GROUP)

                         AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                         TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.


        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: V4

TYPE        PART OF MODEL                SSH        SSE        MSH        MSE     F-RATIO     DFH      DFE     PROB

UNIV   GRAND MEAN                      66.04       0.01      66.04 0.4093E-3  161320.11     1.0     27.0  0.0
UNIV   GROUP                       0.5539E-2       0.01  0.1846E-2 0.4093E-3       4.51     3.0     27.0  0.01089
ERROR  TERM: CASES(GROUP)

UNIV   TIME                        0.7836E-4  0.3792E-3  0.7836E-4 0.1404E-4       5.58     1.0     27.0  0.02565
UNIV   GROUP*TIME                  0.8751E-4  0.3792E-3  0.2917E-4 0.1404E-4       2.08     3.0     27.0  0.12680
UNIV   CASES(GROUP)               *     0.01  0.3792E-3  0.4093E-3 0.1404E-4      29.14    27.0     27.0  .740E-13
UNIV   TIME*CASES(GROUP)          *0.3792E-3       ****  0.1404E-4      ****       ****    27.0     ****     ****
ERROR  TERM: TIME*CASES(GROUP)

                         AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                         TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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         UNIQUE         SUMMARY TABLE OF F-RATIOS FOR: V7

TYPE      PART OF MODEL                         SSH        SSE        MSH        MSE     F-RATIO      DFH      DFE    PROB

UNIV  GRAND MEAN                            26457.93    1921.70  26457.93      71.17     371.74       1.0     27.0 .257E-16
UNIV  GROUP                                   940.41    1921.70    313.47      71.17       4.40       3.0     27.0 0.01203
ERROR TERM: CASES(GROUP)

UNIV  TIME                                     13.24      65.14     13.24       2.41       5.49       1.0     27.0 0.02680
UNIV  GROUP*TIME                               15.54      65.14      5.18       2.41       2.15       3.0     27.0 0.11756
UNIV  CASES(GROUP)                        *  1921.70      65.14     71.17       2.41      29.50      27.0     27.0 .635E-13
UNIV  TIME*CASES(GROUP)                   *    65.14       ****      2.41       ****       ****      27.0     ****    ****
ERROR TERM: TIME*CASES(GROUP)

                          AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                          TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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         UNIQUE         SUMMARY TABLE OF F-RATIOS FOR: V10

TYPE      PART OF MODEL                         SSH        SSE        MSH        MSE     F-RATIO      DFH      DFE    PROB

UNIV  GRAND MEAN                            18550.01    2462.12  18550.01      91.19     203.42       1.0     27.0 .433E-13
UNIV  GROUP                                   958.42    2462.12    319.47      91.19       3.50       3.0     27.0 0.02884
ERROR TERM: CASES(GROUP)

UNIV  TIME                                      9.61      42.11      9.61       1.56       6.16       1.0     27.0 0.01956
UNIV  GROUP*TIME                               15.32      42.11      5.11       1.56       3.27       3.0     27.0 0.03628
UNIV  CASES(GROUP)                        *  2462.12      42.11     91.19       1.56      58.47      27.0     27.0 .933E-17
UNIV  TIME*CASES(GROUP)                   *    42.11       ****      1.56       ****       ****      27.0     ****    ****
ERROR TERM: TIME*CASES(GROUP)

                          AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                          TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: V13

TYPE      PART OF MODEL                         SSH        SSE        MSH       MSE   F-RATIO    DFH     DFE      PROB

UNIV  GRAND MEAN                          247679.17    1604.48  247679.17     59.43   4167.92    1.0    27.0  .398E-30
UNIV  GROUP                                  369.53    1604.48     123.18     59.43      2.07    3.0    27.0  0.12735
ERROR TERM: CASES(GROUP)

UNIV  TIME                                     6.11      56.80       6.11      2.10      2.90    1.0    27.0  0.09985
UNIV  GROUP*TIME                               3.89      56.80       1.30      2.10      0.62    3.0    27.0  0.61006
UNIV  CASES(GROUP)                     *    1604.48      56.80      59.43      2.10     28.25   27.0    27.0  .109E-12
UNIV  TIME*CASES(GROUP)                *      56.80       ****       2.10      ****      ****   27.0    ****   ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.



          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: V1

TYPE      PART OF MODEL                         SSH        SSE        MSH       MSE   F-RATIO    DFH     DFE      PROB

UNIV  GRAND MEAN                            7010.68     698.71    7010.68     27.95    250.84    1.0    25.0  .152E-13
UNIV  GROUP                                  151.38     698.71      50.46     27.95      1.81    3.0    25.0  0.17198
ERROR TERM: CASES(GROUP)

UNIV  TIME                                     3.61      26.83       3.61      1.07      3.37    1.0    25.0  0.07849
UNIV  GROUP*TIME                               1.62      26.83       0.54      1.07      0.50    3.0    25.0  0.68307
UNIV  CASES(GROUP)                     *     698.71      26.83      27.95      1.07     26.04   25.0    25.0  .223E-11
UNIV  TIME*CASES(GROUP)                *      26.83       ****       1.07      ****      ****   25.0    ****   ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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         UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: V4

TYPE      PART OF MODEL                 SSH        SSE        MSH        MSE    F-RATIO     DFH     DFE   PROB

UNIV  GRAND MEAN                    16244.29    2675.70   16244.29    107.03    151.78     1.0    25.0 .407E-11
UNIV  GROUP                           790.60    2675.70     263.53    107.03      2.46     3.0    25.0 0.08593
ERROR TERM: CASES(GROUP)

UNIV  TIME                              0.33      21.66       0.33      0.87      0.38     1.0    25.0 0.54386
UNIV  GROUP*TIME                       17.39      21.66       5.80      0.87      6.69     3.0    25.0 0.00181
UNIV  CASES(GROUP)               *   2675.70      21.66     107.03      0.87    123.52    25.0    25.0 .156E-19
UNIV  TIME*CASES(GROUP)          *     21.66       ****       0.87      ****      ****    25.0    ****   ****
ERROR TERM: TIME*CASES(GROUP)

                  AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                  TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.




         UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: V7

TYPE      PART OF MODEL                 SSH        SSE        MSH        MSE    F-RATIO     DFH     DFE   PROB

UNIV  GRAND MEAN                    14054.18    3272.16   14054.18    130.89    107.38     1.0    25.0 0.155E-9
UNIV  GROUP                           377.56    3272.16     125.85    130.89      0.96     3.0    25.0 0.42628
ERROR TERM: CASES(GROUP)

UNIV  TIME                              4.13      68.04       4.13      2.72      1.52     1.0    25.0 0.22967
UNIV  GROUP*TIME                       37.11      68.04      12.37      2.72      4.54     3.0    25.0 0.01126
UNIV  CASES(GROUP)               *   3272.16      68.04     130.89      2.72     48.09    25.0    25.0 .155E-14
UNIV  TIME*CASES(GROUP)          *     68.04       ****       2.72      ****      ****    25.0    ****   ****
ERROR TERM: TIME*CASES(GROUP)

                  AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                  TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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                                   SUMMARY TABLE OF F-RATIOS FOR: V10
              UNIQUE
                                                  SSH        SSE        MSH        MSE    F-RATIO   DFH    DFE    PROB
TYPE       PART OF MODEL

UNIV   GRAND MEAN                           31204.32    4523.39   31204.32     180.94    172.46    1.0   25.0  .101E-11
UNIV   GROUP                                  750.94    4523.39     250.31     180.94      1.38    3.0   25.0  0.27087
ERROR TERM: CASES(GROUP)

UNIV   TIME                                     1.02     233.15       1.02       9.33      0.11    1.0   25.0  0.74303
UNIV   GROUP*TIME                              79.15     233.15      26.38       9.33      2.83    3.0   25.0  0.05894
UNIV   CASES(GROUP)                     *    4523.39     233.15     180.94       9.33     19.40   25.0   25.0  .662E-10
UNIV   TIME*CASES(GROUP)                *     233.15       ****       9.33       ****      ****   25.0   ****  ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.



                                   SUMMARY TABLE OF F-RATIOS FOR: V13
              UNIQUE
                                                  SSH        SSE        MSH        MSE    F-RATIO   DFH    DFE    PROB
TYPE       PART OF MODEL

UNIV   GRAND MEAN                            1760.52     250.29    1760.52      10.01    175.85    1.0   25.0  .819E-12
UNIV   GROUP                                   43.61     250.29      14.54      10.01      1.45    3.0   25.0  0.25156
ERROR TERM: CASES(GROUP)

UNIV   TIME                                     0.55       4.77       0.55       0.19      2.89    1.0   25.0  0.10127
UNIV   GROUP*TIME                               0.59       4.77       0.20       0.19      1.03    3.0   25.0  0.39696
UNIV   CASES(GROUP)                     *     250.29       4.77      10.01       0.19     52.49   25.0   25.0  .541E-15
UNIV.  TIME*CASES(GROUP)                *       4.77       ****       0.19       ****      ****   25.0   ****  ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: V22

TYPE      PART OF MODEL                          SSH       SSE       MSH       MSE    F-RATIO     DFH      DFE    PROB

UNIV  GRAND MEAN                           530301.77  57979.11 530301.77   2319.16    228.66     1.0     25.0 .437E-13
UNIV  GROUP                                 13548.42  57979.11   4516.14   2319.16      1.95     3.0     25.0 0.14780
ERROR TERM: CASES(GROUP)

UNIV  TIME                                      9.72    680.21      9.72     27.21      0.36     1.0     25.0 0.55548
UNIV  GROUP*TIME                              570.87    680.21    190.29     27.21      6.99     3.0     25.0 0.00142
UNIV  CASES(GROUP)                        * 57979.11    680.21   2319.16     27.21     85.24    25.0     25.0 .149E-17
UNIV  TIME*CASES(GROUP)                   *   680.21      ****     27.21      ****      ****    25.0     ****   ****
ERROR TERM: TIME*CASES(GROUP)

                          AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                          TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.



        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: V1

TYPE      PART OF MODEL                          SSH       SSE       MSH       MSE    F-RATIO     DFH      DFE    PROB

UNIV  GRAND MEAN                           503746.86   6288.24 503746.86    285.83   1762.41     1.0     22.0 .169E-21
UNIV  GROUP                                  1117.62   6288.24    558.81    285.83      1.96     2.0     22.0 0.16538
ERROR TERM: CASES(GROUP)

UNIV  TIME                                      3.89     26.30      1.94      0.60      3.25     2.0     44.0 0.04823
 GREENHOUSE-GEISER ADJ:                     EPSILON:      0.99      1.94      0.60      3.25     2.0     43.5 0.04884
UNIV  GROUP*TIME                                9.13     26.30      2.28      0.60      3.82     4.0     44.0 0.00846
 GREENHOUSE-GEISER ADJ:                     EPSILON:      0.99      2.28      0.60      3.82     4.0     43.5 0.00974
UNIV  CASES(GROUP)                        *  6288.24     26.30    285.83      0.60    478.21    22.0     44.0 .265E-44
UNIV  TIME*CASES(GROUP)                   *    26.30      ****      0.60      ****      ****    44.0     ****   ****
ERROR TERM: TIME*CASES(GROUP)

                          AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                          TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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         UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: V4
                                                SSH        SSE        MSH        MSE     F-RATIO     DFH      DFE     PROB
TYPE       PART OF MODEL
                                               80.16       0.01      80.16 0.5750E-3 139401.39      1.0     22.0 .253E-42
UNIV  GRAND MEAN                          0.1776E-2       0.01 0.8880E-3 0.5750E-3      1.54      2.0     22.0  0.23573
UNIV  GROUP
ERROR TERM: CASES(GROUP)
                                          0.1029E-3  0.6294E-3 0.5149E-4 0.1430E-4      3.60      2.0     44.0  0.03564
UNIV  TIME                                  EPSILON:      0.86 0.5149E-4 0.1430E-4      3.60      1.7     37.9  0.04322
 GREENHOUSE-GEISER ADJ:                   0.1257E-3  0.6294E-3 0.3143E-4 0.1430E-4      2.20      4.0     44.0  0.08482
UNIV  GROUP*TIME                            EPSILON:      0.86 0.3143E-4 0.1430E-4      2.20      3.4     37.9  0.09640
 GREENHOUSE-GEISER ADJ:                  *     0.01  0.6294E-3 0.5750E-3 0.1430E-4     40.20     22.0     44.0 .297E-21
UNIV  CASES(GROUP)                       *0.6294E-3       **** 0.1430E-4      ****      ****     44.0     ****     ****
UNIV  TIME*CASES(GROUP)
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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         UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: V7
                                                SSH        SSE        MSH        MSE     F-RATIO     DFH      DFE     PROB
TYPE       PART OF MODEL
                                         *  39402.59    2231.56   39402.59    101.43    388.45      1.0     22.0 .180E-14
UNIV  GRAND MEAN                              311.51    2231.56     155.76    101.43      1.54      2.0     22.0  0.23754
UNIV  GROUP
ERROR TERM: CASES(GROUP)
                                               17.61     112.06       8.81      2.55      3.46      2.0     44.0  0.04028
UNIV  TIME                                  EPSILON:       0.87       8.81      2.55      3.46      1.7     38.1  0.04789
 GREENHOUSE-GEISER ADJ:                        22.46     112.06       5.62      2.55      2.21      4.0     44.0  0.08394
UNIV  GROUP*TIME                            EPSILON:       0.87       5.62      2.55      2.21      3.5     38.1  0.09506
 GREENHOUSE-GEISER ADJ:                  *   2231.56     112.06     101.43      2.55     39.83     22.0     44.0 .360E-21
UNIV  CASES(GROUP)                       *    112.06       ****       2.55      ****      ****     44.0     ****     ****
UNIV  TIME*CASES(GROUP)
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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          UNIQUE            SUMMARY TABLE OF F-RATIOS FOR: V10

TYPE      PART OF MODEL                               SSH       SSE       MSH       MSE    F-RATIO    DFH    DFE    PROB

UNIV  GRAND MEAN                                 28261.94   3238.32  28261.94    147.20    192.00    1.0   22.0 .239E-11
UNIV  GROUP                                        409.46   3238.32    204.73    147.20      1.39    2.0   22.0 0.26990
ERROR TERM: CASES(GROUP)

UNIV  TIME                                          14.19     84.14      7.10      1.91      3.71    2.0   44.0 0.03240
 GREENHOUSE-GEISER ADJ:                          EPSILON:      0.88      7.10      1.91      3.71    1.8   38.6 0.03884
UNIV  GROUP*TIME                                    20.40     84.14      5.10      1.91      2.67    4.0   44.0 0.04460
 GREENHOUSE-GEISER ADJ:                          EPSILON:      0.88      5.10      1.91      2.67    3.5   38.6 0.05319
UNIV  CASES(GROUP)                            *   3238.32     84.14    147.20      1.91     76.97   22.0   44.0 .381E-27
UNIV  TIME*CASES(GROUP)                       *     84.14      ****      1.91      ****      ****   44.0   ****   ****
ERROR TERM: TIME*CASES(GROUP)

                      AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                      TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.


          UNIQUE            SUMMARY TABLE OF F-RATIOS FOR: V13

TYPE      PART OF MODEL                               SSH       SSE       MSH       MSE    F-RATIO    DFH    DFE    PROB

UNIV  GRAND MEAN                                293372.13   1686.78 293372.13     76.67   3826.33    1.0   22.0 .359E-25
UNIV  GROUP                                        380.35   1686.78    190.17     76.67      2.48    2.0   22.0 0.10681
ERROR TERM: CASES(GROUP)

UNIV  TIME                                           4.85     84.89      2.43      1.93      1.26    2.0   44.0 0.29437
 GREENHOUSE-GEISER ADJ:                          EPSILON:      0.88      2.43      1.93      1.26    1.8   38.7 0.29220
UNIV  GROUP*TIME                                    10.83     84.89      2.71      1.93      1.40    4.0   44.0 0.24865
 GREENHOUSE-GEISER ADJ:                          EPSILON:      0.88      2.71      1.93      1.40    3.5   38.7 0.25393
UNIV  CASES(GROUP)                            *   1686.78     84.89     76.67      1.93     39.74   22.0   44.0 .376E-21
UNIV  TIME*CASES(GROUP)                       *     84.89      ****      1.93      ****      ****   44.0   ****   ****
ERROR TERM: TIME*CASES(GROUP)

                      AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                      TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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        UNIQUE             SUMMARY TABLE OF F-RATIOS FOR: V1

TYPE      PART OF MODEL                            SSH       SSE       MSH       MSE    F-RATIO    DFH    DFE    PROB

UNIV  GRAND MEAN                              10423.15    902.91  10423.15     43.00    242.42     1.0   21.0 .523E-12
UNIV  GROUP                                      42.98    902.91     21.49     43.00      0.50     2.0   21.0 0.61369
ERROR TERM: CASES(GROUP)

UNIV  TIME                                        6.23     35.99      3.11      0.86      3.63     2.0   42.0 0.03505
 GREENHOUSE-GEISER ADJ:                       EPSILON:      0.80      3.11      0.86      3.63     1.6   33.6 0.04643
UNIV  GROUP*TIME                                  0.55     35.99      0.14      0.86      0.16     4.0   42.0 0.95756
 GREENHOUSE-GEISER ADJ:                       EPSILON:      0.80      0.14      0.86      0.16     3.2   33.6 0.93162
UNIV  CASES(GROUP)                          *   902.91     35.99     43.00      0.86     50.17    21.0   42.0 .320E-22
UNIV  TIME*CASES(GROUP)                     *    35.99      ****      0.86      ****      ****    42.0   ****   ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.



        UNIQUE             SUMMARY TABLE OF F-RATIOS FOR: V4

TYPE      PART OF MODEL                            SSH       SSE       MSH       MSE    F-RATIO    DFH    DFE    PROB

UNIV  GRAND MEAN                              25892.36   3866.02  25892.36    184.10    140.65     1.0   21.0 .904E-10
UNIV  GROUP                                     463.54   3866.02    231.77    184.10      1.26     2.0   21.0 0.30452
ERROR TERM: CASES(GROUP)

UNIV  TIME                                        8.39     49.80      4.19      1.19      3.54     2.0   42.0 0.03803
 GREENHOUSE-GEISER ADJ:                       EPSILON:      0.81      4.19      1.19      3.54     1.6   33.9 0.04932
UNIV  GROUP*TIME                                  9.16     49.80      2.29      1.19      1.93     4.0   42.0 0.12304
 GREENHOUSE-GEISER ADJ:                       EPSILON:      0.81      2.29      1.19      1.93     3.2   33.9 0.13956
UNIV  CASES(GROUP)                          *  3866.02     49.80    184.10      1.19    155.25    21.0   42.0 .352E-32
UNIV  TIME*CASES(GROUP)                     *    49.80      ****      1.19      ****      ****    42.0   ****   ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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       UNIQUE           SUMMARY TABLE OF F-RATIOS FOR: V7
TYPE       PART OF MODEL                         SSH        SSE        MSH        MSE     F-RATIO     DFH     DFE     PROB

UNIV  GRAND MEAN                             21499.40    4522.00   21499.40    215.33     99.84      1.0    21.0 0.196E-8
UNIV  GROUP                                     77.25    4522.00      38.62    215.33      0.18      2.0    21.0  0.83707
ERROR TERM: CASES(GROUP)

UNIV  TIME                                       2.25     116.07       1.12      2.76      0.41      2.0    42.0  0.66869
  GREENHOUSE-GEISER ADJ:                     EPSILON:       0.95       1.12      2.76      0.41      1.9    39.9  0.65853
UNIV  GROUP*TIME                                36.80     116.07       9.20      2.76      3.33      4.0    42.0  0.01864
  GREENHOUSE-GEISER ADJ:                     EPSILON:       0.95       9.20      2.76      3.33      3,8    39.9  0.02072
UNIV  CASES(GROUP)                       *    4522.00     116.07     215.33      2.76     77.92     21.0    42.0 .469E-26
UNIV  TIME*CASES(GROUP)                  *     116.07       ****       2.76      ****      ****     42.0    ****     ****
ERROR TERM: TIME*CASES(GROUP)

                  AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                  TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.


       UNIQUE           SUMMARY TABLE OF F-RATIOS FOR: V10
TYPE       PART OF MODEL                         SSH        SSE        MSH        MSE     F-RATIO     DFH     DFE     PROB

UNIV  GRAND MEAN                             46993.58    5335.23   46993.58    254.06    184.97      1.0    21.0 .700E-11
UNIV  GROUP                                    280.64    5335.23     140.32    254.06      0.55      2.0    21.0  0.58376
ERROR TERM: CASES(GROUP)

UNIV  TIME                                       0.99     295.72       0.50      7.04      0.07      2.0    42.0  0.93210
  GREENHOUSE-GEISER ADJ:                     EPSILON:       0.75       0.50      7.04      0.07      1.5    31.6  0.88445
UNIV  GROUP*TIME                                70.31     295.72      17.58      7.04      2.50      4.0    42.0  0.05710
  GREENHOUSE-GEISER ADJ:                     EPSILON:       0.75      17.58      7.04      2.50      3.0    31.6  0.07746
UNIV  CASES(GROUP)                       *    5335.23     295.72     254.06      7.04     36.08     21.0    42.0 .208E-19
UNIV  TIME*CASES(GROUP)                  *     295.72       ****       7.04      ****      ****     42.0    ****     ****
ERROR TERM: TIME*CASES(GROUP)

                  AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                  TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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         UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: V13

TYPE      PART OF MODEL                     SSH      SSE      MSH      MSE    F-RATIO   DFH    DFE   PROB

UNIV  GRAND MEAN                        2619.63   365.44  2619.63    17.40   150.54    1.0   21.0 .483E-10
UNIV  GROUP                               21.33   365.44    10.66    17.40     0.61    2.0   21.0 0.55122
ERROR TERM: CASES(GROUP)

UNIV  TIME                                 0.64     6.59     0.32     0.16     2.05    2.0   42.0 0.14148
 GREENHOUSE-GEISER ADJ:                EPSILON:     0.85     0.32     0.16     2.05    1.7   35.7 0.14966
UNIV  GROUP*TIME                           0.63     6.59     0.16     0.16     1.00    4.0   42.0 0.41865
 GREENHOUSE-GEISER ADJ:                EPSILON:     0.85     0.16     0.16     1.00    3.4   35.7 0.41175
UNIV  CASES(GROUP)                    *  365.44     6.59    17.40     0.16   110.89   21.0   42.0 .354E-29
UNIV  TIME*CASES(GROUP)               *    6.59     ****     0.16     ****     ****   42.0   ****  ****
ERROR TERM: TIME*CASES(GROUP)

                     AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                     TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.



         UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: V16

TYPE      PART OF MODEL                     SSH      SSE      MSH      MSE    F-RATIO   DFH    DFE   PROB

UNIV  GRAND MEAN                       18294.93  1802.20 18294.93    85.82   213.18    1.0   21.0 .180E-11
UNIV  GROUP                              174.82  1802.20    87.41    85.82     1.02    2.0   21.0 0.37828
ERROR TERM: CASES(GROUP)

UNIV  TIME                                11.35    97.28     5.67     2.32     2.45    2.0   42.0 0.09853
 GREENHOUSE-GEISER ADJ:                EPSILON:     0.96     5.67     2.32     2.45    1.9   40.3 0.10104
UNIV  GROUP*TIME                          10.21    97.28     2.55     2.32     1.10    4.0   42.0 0.36808
 GREENHOUSE-GEISER ADJ:                EPSILON:     0.96     2.55     2.32     1.10    3.8   40.3 0.36749
UNIV  CASES(GROUP)                    * 1802.20    97.28    85.82     2.32    37.05   21.0   42.0 .124E-19
UNIV  TIME*CASES(GROUP)               *   97.28     ****     2.32     ****     ****   42.0   ****  ****
ERROR TERM: TIME*CASES(GROUP)

                     AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                     TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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      UNIQUE            SUMMARY TABLE OF F-RATIOS FOR: V19

TYPE      PART OF MODEL                SSH       SSE       MSH       MSE     F-RATIO    DFH     DFE   PROB

UNIV  GRAND MEAN                    7427.91   1175.26   7427.91     55.96    132.72     1.0    21.0 0.153E-9
UNIV  GROUP                           10.25   1175.26      5.12     55.96      0.09     2.0    21.0 0.91288
ERROR TERM: CASES(GROUP)

UNIV  TIME                             2.61     29.24      1.30      0.70      1.87     2.0    42.0 0.16626
  GREENHOUSE-GEISER ADJ:           EPSILON:      0.81      1.30      0.70      1.87     1.6    34.0 0.17493
UNIV  GROUP*TIME                       0.97     29.24      0.24      0.70      0.35     4.0    42.0 0.84341
  GREENHOUSE-GEISER ADJ:           EPSILON:      0.81      0.24      0.70      0.35     3.2    34.0 0.80507
UNIV  CASES(GROUP)                * 1175.26     29.24     55.96      0.70     80.38    21.0    42.0 .249E-26
UNIV  TIME*CASES(GROUP)           *   29.24      ****      0.70      ****      ****    42.0    ****  ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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      UNIQUE            SUMMARY TABLE OF F-RATIOS FOR: V22

TYPE      PART OF MODEL                SSH       SSE       MSH       MSE     F-RATIO    DFH     DFE   PROB

UNIV  GRAND MEAN                  808172.27  78759.64 808172.27   3750.46    215.49     1.0    21.0 .163E-11
UNIV  GROUP                         4516.98  78759.64   2258.49   3750.46      0.60     2.0    21.0 0.55680
ERROR TERM: CASES(GROUP)

UNIV  TIME                            16.12    868.93      8.06     20.69      0.39     2.0    42.0 0.67970
  GREENHOUSE-GEISER ADJ:           EPSILON:      0.89      8.06     20.69      0.39     1.8    37.2 0.65505
UNIV  GROUP*TIME                     450.09    868.93    112.52     20.69      5.44     4.0    42.0 0.00127
  GREENHOUSE-GEISER ADJ:           EPSILON:      0.89    112.52     20.69      5.44     3.5    37.2 0.00213
UNIV  CASES(GROUP)               * 78759.64    868.93   3750.46     20.69    181.28    21.0    42.0 .143E-33
UNIV  TIME*CASES(GROUP)          *   868.93      ****     20.69      ****      ****    42.0    ****  ****
ERROR TERM: TIME*CASES(GROUP)

                    AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                    TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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        UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: LACT1

TYPE      PART OF MODEL                           SSH       SSE       MSH       MSE    F-RATIO    DFH     DFE    PROB

UNIV  GRAND MEAN                              1511.90     62.85   1511.90      3.49    433.00     1.0    18.0 .485E-13
UNIV  GROUP                                    111.33     62.85     55.67      3.49     15.94     2.0    18.0 0.00010
ERROR TERM: CASES(GROUP)

UNIV  TIME                                       0.01     20.64      0.01      1.15      0.01     1.0    18.0 0.91299
UNIV  GROUP*TIME                                 0.35     20.64      0.18      1.15      0.15     2.0    18.0 0.85789
ERROR TERM: TIME*CASES(GROUP)

UNIV  CONDITIO                                 406.81     33.03    203.40      0.92    221.71     2.0    36.0 .576E-20
 GREENHOUSE-GEISER ADJ:                      EPSILON:      0.63    203.40      0.92    221.71     1.3    22.5 .637E-13
UNIV  GROUP*CONDITIO                            47.30     33.03     11.82      0.92     12.89     4.0    36.0 0.130E-5
 GREENHOUSE-GEISER ADJ:                      EPSILON:      0.63     11.82      0.92     12.89     2.5    22.5 0.00008
ERROR TERM: CONDITIO*CASES(GROUP)

UNIV  TIME*CONDITIO                              0.97     16.36      0.49      0.45      1.07     2.0    36.0 0.35393
 GREENHOUSE-GEISER ADJ:                      EPSILON:      0.69      0.49      0.45      1.07     1.4    24.8 0.33478
UNIV  GROUP*TIME*CONDITIO                        1.56     16.36      0.39      0.45      0.86     4.0    36.0 0.49986
 GREENHOUSE-GEISER ADJ:                      EPSILON:      0.69      0.39      0.45      0.86     2.8    24.8 0.46904
UNIV  CASES(GROUP)                         *    62.85     16.36      3.49      0.45      7.68    18.0    36.0 0.128E-6
UNIV  TIME*CASES(GROUP)                    *    20.64     16.36      1.15      0.45      2.52    18.0    36.0 0.00889
UNIV  CONDITIO*CASES(GROUP)                *    33.03     16.36      0.92      0.45      2.02    36.0    36.0 0.01914
UNIV  TIME*CONDITIO*CASES(GROUP)           *    16.36      ****      0.45      ****      ****    36.0    ****  ****
ERROR TERM: TIME*CONDITIO*CASES(GROUP)

                        AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                        TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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         UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: DIF3

TYPE       PART OF MODEL                     SSH       SSE       MSH       MSE     F-RATIO    DFH     DFE   PROB

UNIV  GRAND MEAN                             4.73      9.84      4.73      0.55      8.65     1.0    18.0 0.00872
UNIV  GROUP                                 14.77      9.84      7.39      0.55     13.51     2.0    18.0 0.00026
ERROR TERM: CASES(GROUP)

UNIV  TIME                                   1.40      5.46      1.40      0.30      4.60     1.0    18.0 0.04591
UNIV  GROUP*TIME                             2.10      5.46      1.05      0.30      3.46     2.0    18.0 0.05344
UNIV  CASES(GROUP)                       *   9.84      5.46      0.55      0.30      1.80    18.0    18.0 0.11071
UNIV  TIME*CASES(GROUP)                  *   5.46      ****      0.30      ****      ****    18.0    ****   ****
ERROR TERM: TIME*CASES(GROUP)

                       AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                       TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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         UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: P01

TYPE       PART OF MODEL                     SSH       SSE       MSH       MSE     F-RATIO    DFH     DFE   PROB

UNIV  GRAND MEAN                       0.17530E9 0.50258E7 0.17530E9 228449.68    767.36     1.0    22.0 .134E-17
UNIV  GROUP                            0.11567E8 0.50258E7 0.57838E7 228449.68     25.32     2.0    22.0 0.196E-5
ERROR TERM: CASES(GROUP)

UNIV  TIME                             586408.79 495678.57 195469.60   7510.28     26.03     3.0    66.0 .316E-10
  GREENHOUSE-GEISER ADJ:                EPSILON:      0.67 195469.60   7510.28     26.03     2.0    44.5 0.300E-7
UNIV  GROUP*TIME                        81921.43 495678.57  13653.57   7510.28      1.82     6.0    66.0  0.10901
  GREENHOUSE-GEISER ADJ:                EPSILON:      0.67  13653.57   7510.28      1.82     4.0    44.5  0.14162
UNIV  CASES(GROUP)                     *0.50258E7 495678.57 228449.68   7510.28     30.42    22.0    66.0 .219E-25
UNIV  TIME*CASES(GROUP)                *495678.57      ****   7510.28      ****      ****    66.0    ****   ****
ERROR TERM: TIME*CASES(GROUP)

                       AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                       TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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             UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: DIF1

TYPE      PART OF MODEL                     SSH       SSE       MSH       MSE     F-RATIO    DFH    DFE    PROB

UNIV  GRAND MEAN                          1213.32     84.32   1213.32     4.68    259.00     1.0   18.0 .394E-11
UNIV  GROUP                                119.73     84.32     59.87     4.68     12.78     2.0   18.0 0.00035
ERROR TERM: CASES(GROUP)

UNIV  TIME                                   0.82     40.89      0.82     2.27      0.36     1.0   18.0 0.55483
UNIV  GROUP*TIME                             1.51     40.89      0.76     2.27      0.33     2.0   18.0 0.72101
ERROR TERM: TIME*CASES(GROUP)

UNIV  CONDITIO                               2.37      4.92      2.37     0.27      8.65     1.0   18.0 0.00872
UNIV  GROUP*CONDITIO                         7.39      4.92      3.69     0.27     13.51     2.0   18.0 0.00026
ERROR TERM: CONDITIO*CASES(GROUP)

UNIV  TIME*CONDITIO                          0.70      2.73      0.70     0.15      4.60     1.0   18.0 0.04591
UNIV  GROUP*TIME*CONDITIO                    1.05      2.73      0.53     0.15      3.46     2.0   18.0 0.05344
UNIV  CASES(GROUP)                      *   84.32      2.73      4.68     0.15     30.88    18.0   18.0 0.569E-9
UNIV  TIME*CASES(GROUP)                 *   40.89      2.73      2.27     0.15     14.97    18.0   18.0 0.226E-6
UNIV  CONDITIO*CASES(GROUP)             *    4.92      2.73      0.27     0.15      1.80    18.0   18.0 0.11071
UNIV  TIME*CONDITIO*CASES(GROUP)        *    2.73      ****      0.15     ****      ****    18.0   ****   ****
ERROR TERM: TIME*CONDITIO*CASES(GROUP)

                 AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                 TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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       UNIQUE           SUMMARY TABLE OF F-RATIOS FOR: FA1
                                                    SSH        SSE        MSH        MSE     F-RATIO    DFH     DFE   PROB
TYPE      PART OF MODEL

UNIV  GRAND MEAN                             0.28005E8 0.14462E7 0.28005E8   90392.25     309.82    1.0    16.0 .679E-11
UNIV  GROUP                                   29247.10 0.14462E7  14623.55   90392.25       0.16    2.0    16.0 0.85200
ERROR TERM: CASES(GROUP)

UNIV  TIME                                   403830.49 0.12608E7 403830.49   78802.75       5.12    1.0    16.0 0.03784
UNIV  GROUP*TIME                             158067.56 0.12608E7  79033.78   78802.75       1.00    2.0    16.0 0.38873
ERROR TERM: TIME*CASES(GROUP)

UNIV  CONDITIO                               163769.53 172734.75  81884.76    5397.96      15.17    2.0    32.0 0.00002
 GREENHOUSE-GEISER ADJ:                       EPSILON:      0.71  81884.76    5397.96      15.17    1.4    22.8 0.00023
UNIV  GROUP*CONDITIO                          65714.31 172734.75  16428.58    5397.96       3.04    4.0    32.0 0.03111
 GREENHOUSE-GEISER ADJ:                       EPSILON:      0.71  16428.58    5397.96       3.04    2.9    22.8 0.05157
ERROR TERM: CONDITIO*CASES(GROUP)

UNIV  TIME*CONDITIO                             289.23 359365.05    144.61   11230.16       0.01    2.0    32.0 0.98721
 GREENHOUSE-GEISER ADJ:                       EPSILON:      0.85    144.61   11230.16       0.01    1.7    27.3 0.97773
UNIV  GROUP*TIME*CONDITIO                     58422.13 359365.05  14605.53   11230.16       1.30    4.0    32.0 0.29073
 GREENHOUSE-GEISER ADJ:                       EPSILON:      0.85  14605.53   11230.16       1.30    3.4    27.3 0.29474
UNIV  CASES(GROUP)                          *0.14462E7 359365.05  90392.25   11230.16       8.05   16.0    32.0 0.349E-6
UNIV  TIME*CASES(GROUP)                     *0.12608E7 359365.05  78802.75   11230.16       7.02   16.0    32.0 0.164E-5
UNIV  CONDITIO*CASES(GROUP)                 *172734.75 359365.05   5397.96   11230.16       0.48   32.0    32.0 0.97901
UNIV  TIME*CONDITIO*CASES(GROUP)            *359365.05      ****  11230.16       ****       ****   32.0    ****   ****
ERROR TERM: TIME*CONDITIO*CASES(GROUP)

                      AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                      TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: TIME1
TYPE      PART OF MODEL                        SSH        SSE        MSH        MSE     F-RATIO    DFH      DFE    PROB

UNIV  GRAND MEAN                          36063.25     822.78   36063.25      37.40     964.28     1.0     22.0 .115E-18
UNIV  GROUP                                1702.50     822.78     851.25      37.40      22.76     2.0     22.0 0.439E-5
ERROR TERM: CASES(GROUP)

UNIV  TIME                                   17.62     270.67       5.87       4.10       1.43     3.0     66.0 0.24122
 GREENHOUSE-GEISER ADJ:                   EPSILON:       0.52       5.87       4.10       1.43     1.6     34.5 0.25049
UNIV  GROUP*TIME                             15.56     270.67       2.59       4.10       0.63     6.0     66.0 0.70377
 GREENHOUSE-GEISER ADJ:                   EPSILON:       0.52       2.59       4.10       0.63     3.1     34.5 0.60609
UNIV  CASES(GROUP)                      *   822.78     270.67      37.40       4.10       9.12    22.0     66.0 .120E-11
UNIV  TIME*CASES(GROUP)                 *   270.67       ****       4.10       ****       ****    66.0     ****    ****
ERROR TERM: TIME*CASES(GROUP)

                         AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                         TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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          UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: BASMEAN
TYPE      PART OF MODEL                       SSH        SSE        MSH        MSE     F-RATIO    DFH      DFE    PROB

UNIV  GRAND MEAN                        0.38276E9  0.19370E8  0.38276E9  0.12106E7     316.17     1.0     16.0 .581E-11
UNIV  GROUP                             0.10570E7  0.19370E8  528508.67  0.12106E7       0.44     2.0     16.0 0.65373
ERROR TERM: CASES(GROUP)

UNIV  TIME                              740065.30  0.49935E7  370032.65  156047.34       2.37     2.0     32.0 0.10957
 GREENHOUSE-GEISER ADJ:                  EPSILON:       0.91  370032.65  156047.34       2.37     1.8     29.0 0.11563
UNIV  GROUP*TIME                        441047.45  0.49935E7  110261.86  156047.34       0.71     4.0     32.0 0.59335
 GREENHOUSE-GEISER ADJ:                  EPSILON:       0.91  110261.86  156047.34       0.71     3.6     29.0 0.58090
UNIV  CASES(GROUP)                     *0.19370E8  0.49935E7  0.12106E7  156047.34       7.76    16.0     32.0 0.532E-6
UNIV  TIME*CASES(GROUP)                *0.49935E7       ****  156047.34       ****       ****    32.0     ****    ****
ERROR TERM: TIME*CASES(GROUP)

                         AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                         TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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         UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: BAS1

 TYPE      PART OF MODEL                         SSH        SSE        MSH        MSE     F-RATIO    DFH     DFE    PROB

 UNIV  GRAND MEAN                        0.52070E9 0.25791E8 0.52070E9 0.16119E7   323.02    1.0    16.0 .493E-11
 UNIV  GROUP                             0.13823E7 0.25791E8 691169.36 0.16119E7     0.43    2.0    16.0 0.65858
 ERROR TERM: CASES(GROUP)

 UNIV  TIME                              966034.61 0.13174E8 322011.54 274476.46     1.17    3.0    48.0 0.32977
  GREENHOUSE-GEISER ADJ:                   EPSILON:     0.80 322011.54 274476.46     1.17    2.4    38.4 0.32650
 UNIV  GROUP*TIME                        0.12687E7 0.13174E8 211459.23 274476.46     0.77    6.0    48.0 0.59694
  GREENHOUSE-GEISER ADJ:                   EPSILON:     0.80 211459.23 274476.46     0.77    4.8    38.4 0.57228
 UNIV  CASES(GROUP)                     *0.25791E8 0.13174E8 0.16119E7 274476.46     5.87   16.0    48.0 0.846E-6
 UNIV  TIME*CASES(GROUP)                *0.13174E8      **** 274476.46      ****     ****   48.0    ****    ****
 ERROR TERM: TIME*CASES(GROUP)

                   AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                   TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
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            UNIQUE          SUMMARY TABLE OF F-RATIOS FOR: DIF1

TYPE       PART OF MODEL                           SSH        SSE        MSH        MSE      F-RATIO      DFH       DFE   PROB

UNIV   GRAND MEAN                             48258.88  330106.18   48258.88   20631.64        2.34       1.0      16.0  0.14569
UNIV   GROUP                                  44218.77  330106.18   22109.39   20631.64        1.07       2.0      16.0  0.36580
ERROR  TERM: CASES(GROUP)

UNIV   TIME                                     317.48  600266.36     317.48   37516.65  0.8462E-2      1.0      16.0  0.92785
UNIV   GROUP*TIME                              5104.70  600266.36    2552.35   37516.65        0.07       2.0      16.0  0.93450
ERROR  TERM: TIME*CASES(GROUP)

UNIV   CONDITIO                              147683.23   62699.35  147683.23    3918.71       37.69       1.0      16.0  0.00001
UNIV   GROUP*CONDITIO                         50974.72   62699.35   25487.36    3918.71        6.50       2.0      16.0  0.00857
ERROR  TERM: CONDITIO*CASES(GROUP)

UNIV   TIME*CONDITIO                            183.40  159276.26     183.40    9954.77        0.02       1.0      16.0  0.89373
UNIV   GROUP*TIME*CONDITIO                    56720.56  159276.26   28360.28    9954.77        2.85       2.0      16.0  0.08742
UNIV   CASES(GROUP)                         *330106.18  159276.26   20631.64    9954.77        2.07      16.0      16.0  0.07783
UNIV   TIME*CASES(GROUP)                    *600266.36  159276.26   37516.65    9954.77        3.77      16.0      16.0  0.00576
UNIV   CONDITIO*CASES(GROUP)                * 62699.35  159276.26    3918.71    9954.77        0.39      16.0      16.0  0.96442
UNIV   TIME*CONDITIO*CASES(GROUP)           *159276.26       ****    9954.77       ****        ****      16.0      ****   ****
ERROR  TERM: TIME*CONDITIO*CASES(GROUP)

                         AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR
                         TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.
```

APPENDIX K

DESCRIPTION OF THE FACULTY OF DENTISTRY NUTRIENT DATA BASE

Introduction

The nutrient data base developed by the Faculty of Dentistry is based on the Kellogg Data Base. In 1985, it was updated with selected information from the 1985 Canadian Nutrient File (CNF, 1985), the United States Department of Agriculture handbooks (USDA, 1976-1984), Canadian food companies, and Pennington and Church's Food Values of Portions Commonly Used (Pennington and Church, 1985). Between 1985 and 1987, selected nutrient values were added from the 1986 Canadian Nutrient File (CNF, 1986) and other published sources (HWC, 1979; 1985; Leveille et al., 1983; Paul and Southgate, 1978; Souci et al., 1981; USDA, 1986).

Food Items

The nutrient data base consists of about 2800 foods which have been divided into 43 groups as listed in Table 1. The categories are based on food types, e.g. Milk, Cream, Whipped Toppings or on common usage, e.g. Desserts.

Within each food group, foods are listed in alphabetical order. For some food groups, e.g. Desserts: Cakes, Cookies, Pastries, Pies, Squares, the food group has been subdivided to aid in locating the food. Each food is in the data base only once even though it could appear in more than one category.

Foods in the data base are in their ready-to-cook, ready-to-heat, or ready-to-eat form as well as in ingredient form. Brand names are used for foods for which the formulation was different from the generic form of the food or for which there did not exist a generic form. Manufacturer or brand names are at the end of a food name, separated from it by a hyphen.

Food names and descriptions are as complete as the information given in the source. Abbreviations are whenever possible the same as those used in the Canadian Nutrient File. A complete list is shown in Table 2.

APPENDIX L

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                         REAL-TIME REPORT
                                                          Page  1

Name:                                         Date:
ID Number: 006                                Time:
                                              Preset Name: CLASSIS#2  (1)

  Time     VE    FEO2   FECO2    O2VE   CO2VE    VO2  VO2/KG   VCO2    RER  Heart    O2
          BTPS                                  STPD           STPD         Rate   Pulse
------------------------------------------------------------------------------------------
   min   L/min                    L/L     L/L  L/min  ml/min  L/min         bts/min ml/bt
                                                        /kg

Measured FIO2 =  0.2096
   0:30   10.5 0.1622 0.0366    26.3    36.5  0.399     5.4  0.288   0.72    62.    6.4
   1:07   12.3 0.1658 0.0357    28.7    37.4  0.427     5.7  0.327   0.77    59.    7.2
   1:36   11.9 0.1632 0.0391    27.4    34.1  0.434     5.9  0.348   0.80    62.    7.0
   2:02   18.5 0.1685 0.0371    31.3    36.0  0.591     8.0  0.514   0.87    59.   10.0
   2:31   14.6 0.1741 0.0355    37.1    37.6  0.392     5.3  0.387   0.99    55.    7.1
   3:02    8.8 0.1681 0.0377    31.1    35.3  0.283     3.8  0.249   0.88    57.    5.0
   3:33    8.0 0.1675 0.0353    30.1    37.8  0.267     3.6  0.212   0.80    59.    4.5
   4:00   11.2 0.1673 0.0346    29.7    38.6  0.378     5.1  0.291   0.77    56.    6.7
   4:33   13.3 0.1659 0.0365    28.9    36.6  0.459     6.2  0.363   0.79    72.    6.4
   5:01   15.0 0.1630 0.0389    27.2    34.2  0.550     7.4  0.437   0.79    64.    8.6
   5:33   13.6 0.1613 0.0415    26.3    32.1  0.518     7.0  0.425   0.82    70.    7.4
   6:01   14.2 0.1637 0.0407    28.0    32.8  0.507     6.8  0.433   0.85    67.    7.6
   6:34   16.4 0.1634 0.0404    27.7    33.0  0.593     8.0  0.497   0.84    73.    8.1
   7:02   17.9 0.1652 0.0386    28.8    34.5  0.621     8.4  0.518   0.83    73.    8.5
   7:31   19.2 0.1644 0.0411    28.5    32.4  0.671     9.0  0.591   0.88    81.    8.3
   8:01   18.6 0.1631 0.0413    27.6    32.3  0.673     9.1  0.576   0.86    79.    8.5
   8:30   21.7 0.1645 0.0410    28.6    32.5  0.759    10.2  0.668   0.88    85.    8.9
   9:02   24.3 0.1614 0.0434    26.7    30.7  0.911    12.3  0.792   0.87    84.   10.8
   9:31   18.0 0.1627 0.0442    27.8    30.2  0.648     8.7  0.596   0.92    85.    7.6
  10:01   27.4 0.1647 0.0430    29.1    31.0  0.941    12.7  0.883   0.94    84.   11.2
  10:33   23.4 0.1613 0.0446    26.8    29.9  0.874    11.8  0.783   0.90    94.    9.3
  11:03   26.7 0.1623 0.0449    27.6    29.7  0.967    13.0  0.898   0.93   100.    9.7
  11:31   27.8 0.1605 0.0462    26.5    28.8  1.050    14.1  0.965   0.92    92.   11.4
  12:02   29.5 0.1631 0.0455    28.3    29.3  1.042    14.0  1.007   0.97   100.   10.4
  12:32   33.5 0.1631 0.0450    28.2    29.6  1.188    16.0  1.132   0.95   110.   10.8
  13:02   36.8 0.1636 0.0453    28.6    29.4  1.288    17.3  1.254   0.97   114.   11.3
  13:33   39.5 0.1625 0.0460    27.9    28.9  1.419    19.1  1.366   0.96   115.   12.3
  14:01   37.8 0.1640 0.0454    28.9    29.4  1.308    17.6  1.288   0.98   121.   10.8
  14:31   45.4 0.1651 0.0447    29.7    29.8  1.529    20.6  1.523   1.00   127.   12.0
  15:02   39.6 0.1620 0.0463    27.5    28.8  1.441    19.4  1.377   0.96   127.   11.3
  15:31   50.6 0.1635 0.0463    28.7    28.8  1.764    23.8  1.760   1.00   131.   13.5
  16:01   53.5 0.1659 0.0465    30.8    28.7  1.739    23.4  1.865   1.07   145.   12.0
  16:31   58.6 0.1674 0.0445    31.7    29.9  1.845    24.8  1.956   1.06   143.   12.9
  17:01   58.4 0.1670 0.0446    31.4    29.8  1.860    25.0  1.958   1.05   152.   12.2
  17:31   70.5 0.1697 0.0434    33.9    30.7  2.078    28.0  2.296   1.10   158.   13.2
*****     MAX Workload  reached at  17:47   *****
  17:46   70.0 0.1706 0.0425    34.7    31.3  2.016    27.2  2.233   1.11   161.   12.5
  17:48   95.7 0.1736 0.0401    37.8    33.3  2.532    34.1  2.876   1.14
```